National Bureau of Standards

National Bureau of Standards

U.S. DEPARTMENT OF COMMERCE

Frederick B. Dent, Secretary

Betsy Ancker-Johnson, Assistant Secretary for Science and Technology

NATIONAL BUREAU OF STANDARDS

Richard W. Roberts, Director

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FROM THE DIRECTOR

There have been two hallmarks of the National Bureau of Standards over the last seven decades: Technical excellence, which is obviously essential to the nation's measurement laboratory, and the versatility to respond to national needs.

At the turn of the century, when the Bureau was founded, American industry was in a period of tremendous growth and innovation. Whole new industrial fields were emerging. Our national and international markets were developing at a rapid pace.

The one thing industry needed most was a solid foundation of national measurement standards. For too long we had been dependent on instruments and technology from Europe. The Bureau did its job well. Many basic electrical measuring instruments developed in those early days bear the names of NBS scientists.

Today the focus is on new national concerns—energy conservation, environmental control, metric conversion, consumer protection, health and safety and a host of other issues. While national concerns change and technologies are constantly developing and becoming more complex, there remains an underlying need for reliable measurements. Measurements are the currency of science and technology, and as such form an indispensable and basic support for the economic strength of nations.

Although to each problem we apply the NBS tradition of excellence, the product is often quite different. We develop measurement standards which are used to keep dangerously flammable fabrics off the consumer market. We develop ways to measure the intensity of noise. We develop new ways of detecting and identifying pollutants in the air and water. We explore alternative sources of energy. We measure the effectiveness of various methods for conserving heat and power in buildings. We develop ways to measure the hazards presented by sharp points and edges in children's toys.

In many cases our measurement expertise is put to work in the development of engineering standards. Staff members contribute their knowledge and experience to the process by which consensus standards are developed for a great variety of products and materials. We are also deeply involved in the development of international standards, an activity of major importance if our technology is to have an impact in world markets.

Note that NBS does not establish or enforce mandatory standards. It develops the measurement methods, instrumentation and measurement standards for others to use, including regulatory agencies. In this country, the vast majority of product standards are voluntary and are developed by such private organizations as the American National Standards Institute, the American Society for Testing and Materials, the Society of Automotive Engineers or any of a number of similar organizations. Even where the federal government has enforcement powers—as with toy safety or flammable fabrics—actual enforcement in the market place rests with the federal regulatory agencies.

It is the Bureau's job to ensure the accuracy and reliability of our measurement foundations for the development of standards, the application of standards to quality control on the production line and, where necessary, the enforcement of standards by law.

Science and technology are dynamic fields. Today's breakthrough is tomorrow's commonplace. To keep up, indeed to anticipate new measurement requirements, NBS maintains a strong foundation in basic science. Research in fundamentals, developments at the frontiers, are needed if we are to do our job well.

Whatever the needs of the American society and of America's people, NBS has many of the resources, dedicated talent, and breadth of experience to respond. This publication is not intended to be a comprehensive review of all the projects or programs of the National Bureau of Standards. Rather, it seeks to show, by selected examples, two things: The broad range of the Bureau's program . . . and the support it gives to areas of vital national interest.

Richard W. Roberts, Director

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This publication provides an overview of the National Bureau of Standards and presents some highlights of the many facets of the nation's largest physical sciences and measurements laboratory. Additional information about any aspect of NBS work may be obtained by calling the Gaithersburg, Maryland facility (301) 921-3181. To reach the Boulder, Colorado laboratories, call (303) 499-1000. Mailing addresses are:

NATIONAL BUREAU OF STANDARDS

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NATIONAL BUREAU OF STANDARDS

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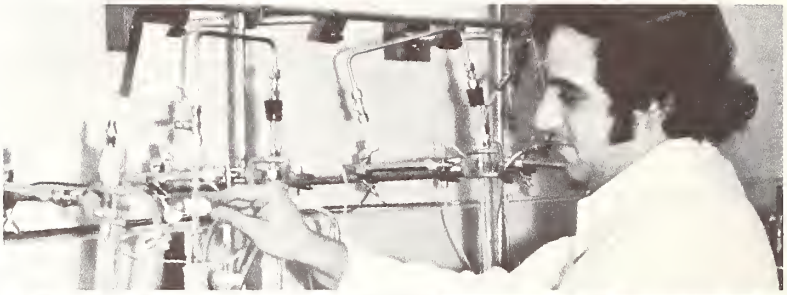
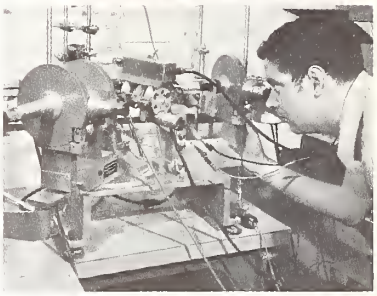
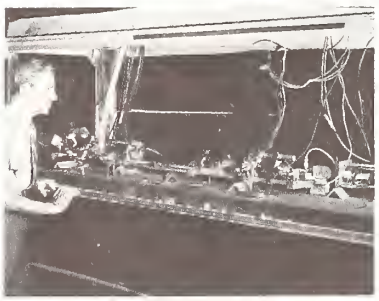
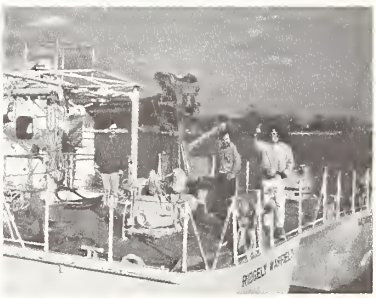
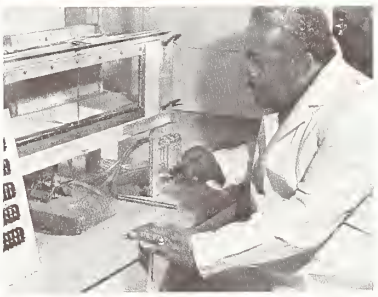










THE LABORATORY

THE LABORATORY

NBS was created by Congress in 1901 to meet the needs of a growing nation for a unified measurement system. For more than 70 years the Bureau has contributed to advances in science and technology, the growth of industry, and efficiency in the marketplace. In so doing, the Bureau has built a scientific facility and staff that stand with the world's best.

The basic enabling legislation of 1901, as amended, establishes these main purposes and functions of the Bureau:

- The custody, maintenance and development of the national standards of measurement, and the provision of means and methods for making measurements consistent with those standards, including the comparison of standards.
- The determination of physical constants and properties of materials, of great importance to scientific or manufacturing interests "and not to be obtained of sufficient accuracy elsewhere."
- The development of methods for testing materials, mechanisms, and structures, and the testing of materials, supplies and equipment.
- Cooperation with other government agencies and with private organizations in the establishment of standard practices incorporated in codes and specifications.
- Advisory service to government agencies on scientific and technical problems.
- Invention and development of devices to serve special needs of the government.

Thus, NBS has both unique and special functions in relation to the nation's science and technology, and very broad responsibilities as well. As part of the U.S. Department of Commerce the Bureau carries out its mission in a variety of ways.

The cornerstone of the NBS mission is to serve, for the United States, as the authoritative source of accurate, compatible, and useful physical measurements and, further, to ensure their international compatibility. As the world's leading technological nation, the United States has a vital interest in ensuring that the world system of measurement is not only internationally compatible but is also sufficiently sophisticated to meet U.S. needs.

NBS provides this resource through participation in the General Conference of Weights and Measures, an international diplomatic conference established by the Treaty of the Meter in 1875. Just recently, the United States also became a member of the International Organization for Legal Metrology, which is concerned with the development and promulgation of recommended laws governing the design and use of commercial and industrial measuring instruments. Representation of the United States has been delegated to NBS. The success of U.S. foreign commerce, as well as the success of international scientific cooperation, depends partly upon the continued progress of such cooperative international endeavors.

In the United States we recognize that buyers and sellers in the marketplace need to have as much confidence in the quantity and performance of goods as they do in the amounts of money paid. A substantial part of NBS measurement research is devoted to the development of fair, objective, and useful measurement methods for goods in trade.

The commercial life of this country depends upon the Bureau's services, because both buyer and seller need an unbiased third party with the technical capability to say "This measurement is fair and accurate; that one is not."

Approximately 350 members of the technical staff of the National Bureau of Standards serve on some 1,150 standardization committees sponsored by private standards-writing organizations. Such participation is an important and desirable way for the technical expertise of NBS to be reflected in industrial practice.

NBS participation is not, however, restricted to technical considerations; there is substantial representation in the major standardization bodies at the policy-making level. For instance, the director of the National Bureau of Standards is, by virtue of his office, on the Board of Directors of the American National Standards Institute. An NBS staff member is also on the Board of Directors of the American Society for Testing and Materials.

NBS assists in the development of the technical base for some of the mandatory standards which the government issues, such as those for consumer products safety, including toys, and has research programs to assist the Environmental Protection Agency in the enforcement of regulatory antipollution standards. In fire safety, NBS provides a technical base for new fire safety standards and develops test methods to evaluate materials used in building construction. In the computer field, NBS develops and recommends to the Secretary of Commerce those Federal Information Standards that will increase the economy and effectiveness of government computer utilization through improved compatibility, interchangeability, and performance of automatic data processing hardware, software, and data bases.

NBS-developed device testing the potential of heated surfaces to burn skin.

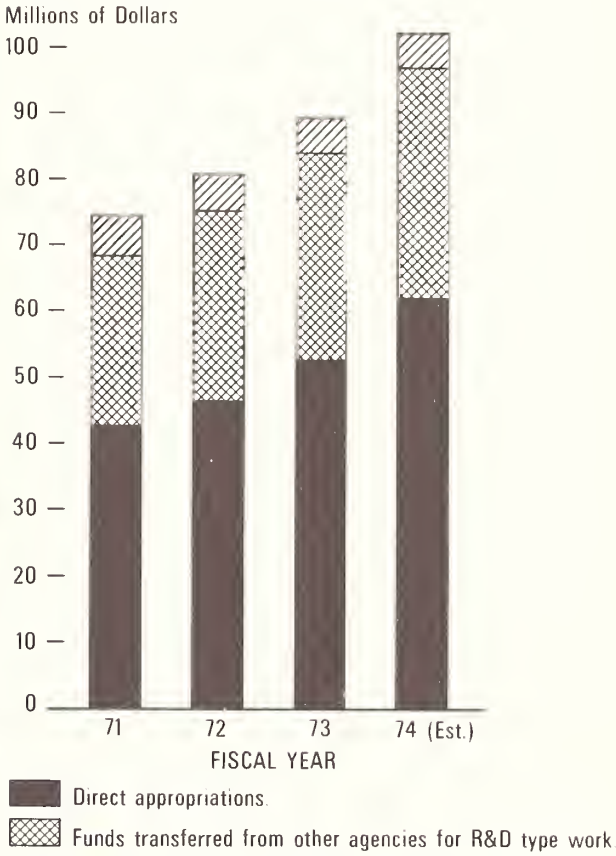
Assistance To Other Agencies

Thirty-eight percent of all the funds expended by NBS are transferred to it from other government agencies in reimbursement for technical and research services. These services range from brief consulting tasks, of days' or weeks' duration, to formal continuing agreements to provide very substantial technical support to aid another department in its decision making.

NBS also operates a standards information service. Each year, it handles about 5,000 inquiries from all sectors of society throughout the world on the availability and source of national, international, foreign national, industry, state and federal government specifications and standards.

In addition, the Department of Commerce, through NBS, operates the Voluntary Product Standards Program. Through this program private groups can develop voluntary engineering standards which the private sector standardization organizations do not generate. The Bureau is now reorienting the program to supplement the ability of private sector organizations to generate voluntary standards in areas of particular concern to the government—particularly in the field of product safety.

TOTAL OPERATING BUDGET

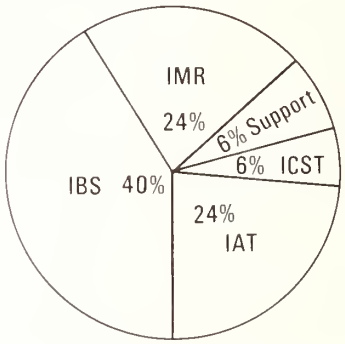


Staff and Facilities

In order to meet growing national needs, the Bureau has been steadily developing its two most important assets—staff and facilities.

The Bureau's principal facilities are located at Gaithersburg, Md., and Boulder, Colo. On the 576-acre Gaithersburg site are 23 buildings containing 111,000 square meters (1.2 million square feet) of working area. NBS required a large site because many of our measurements require maximum isolation from such interference as noise, vibration, and electromagnetic radiation. One of the best means of ensuring isolation is to provide distance between the experiment and interference sources.

NBS
FULL TIME PERMANENT
PROFESSIONAL STAFF



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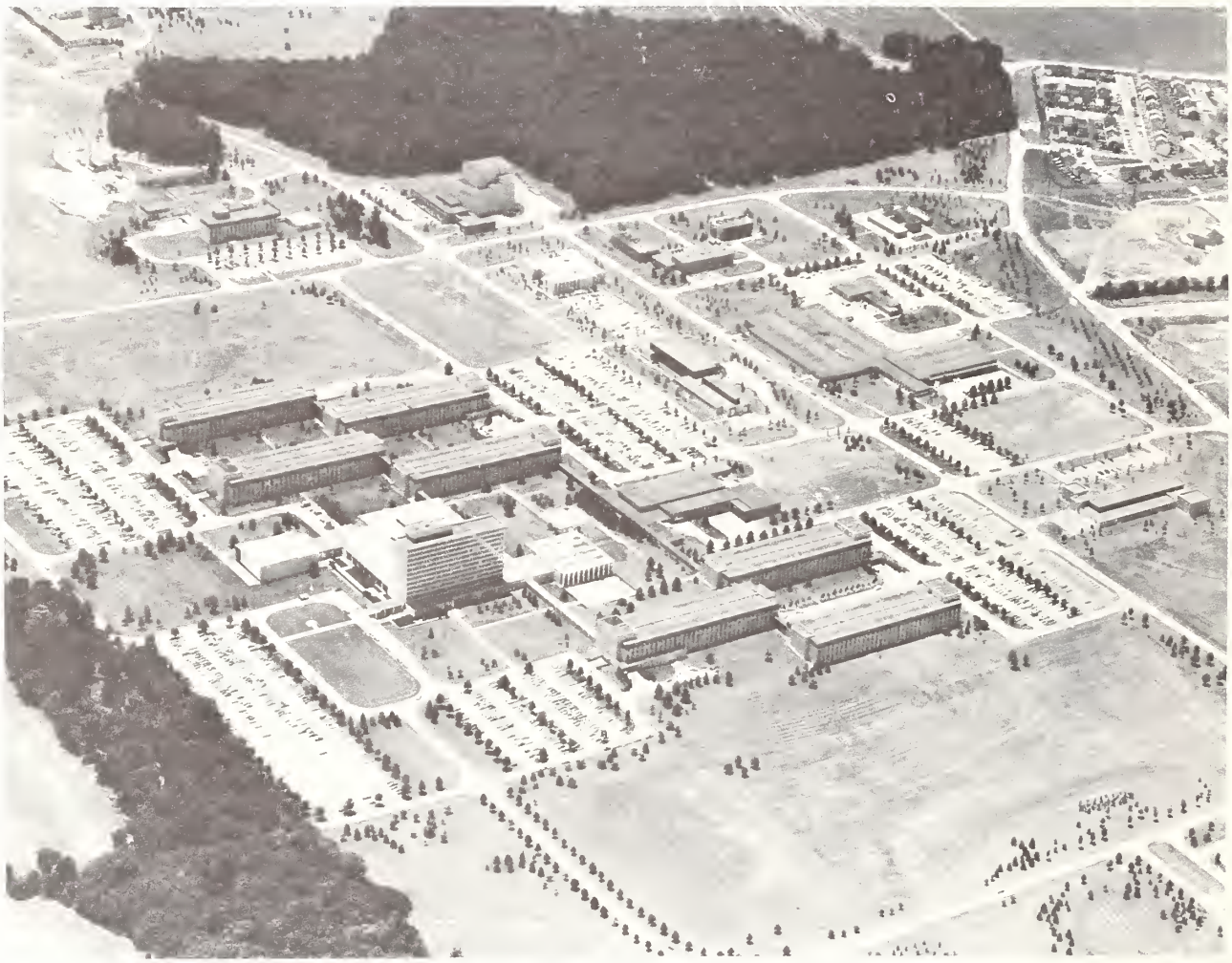


NBS—Gaithersburg, Maryland

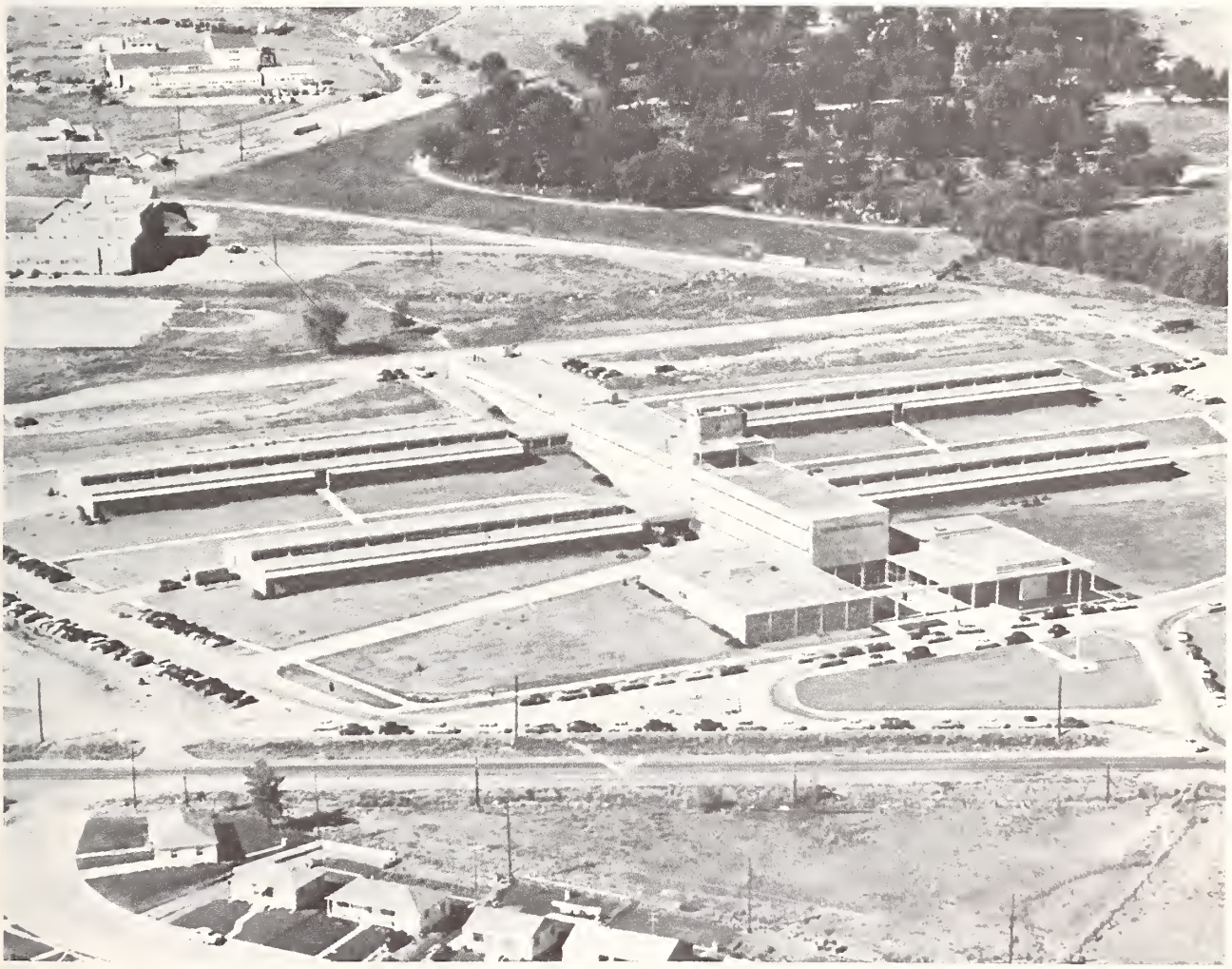
The second major facility, at Boulder, Colo., carries on such work as cryogenics (the production and physics of very low temperatures), electromagnetic measurements, time and frequency standards, and quantum electronics. The Boulder site consists of 205 acres, 14 buildings, and 28,056 assignable square meters (302,000 square feet) of floor space. At Boulder, we also staff and administer jointly with the University of Colorado the Joint Institute for Laboratory Astrophysics, established in 1962 to bring the Bureau's measurement expertise in atomic physics to bear on problems of astrophysics and atmospheric physics.

The Bureau also operates a 380-acre field station at Fort Collins, Colo., for Standard Frequency and Time Interval Broadcast Stations WWV, WWVB, and our experimental station WWVL. Transmitting facilities for WWVH were recently completed on the Island of Kauai in the Hawaiian Islands. NBS also has a Master Railway Scale Facility at Clearing, Illinois.

The work of the Bureau is carried out by a total staff of about 3,600 employees. Eighty-three percent of the staff are at Gaithersburg, Md., and 17 percent are at Boulder, Colorado.

Some 44 percent of the staff are scientists and engineers, 13 percent are technicians. The scientific staff consists of physicists, chemists, engineers, mathematicians, and specialists in other fields. Forty percent of our scientists and engineers have Ph.D. degrees.

In addition, there are normally about 60 industrial research associates and guest workers engaged in projects at the Bureau.



NBS—Boulder, Colorado

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ORGANIZATION AND PROGRAMS

Throughout the thousands of useful projects at NBS runs a common thread: the Bureau helps others with applied research services to produce, diffuse, and enhance the value of practical knowledge. The NBS mission is sufficiently broad to allow the Bureau to respond to changing needs. Such a freedom of choice demands a continual appraisal of the mesh between NBS services and national needs.

Today, the Bureau serves a wide variety of government agencies and works closely with private trade associations, organizations, and professional societies to develop the technical base and standards for many important programs.

Bureau personnel are in the forefront of research on energy conservation. They are involved in the development of the technical base for voluntary and mandatory standards to protect against injury or death from consumer products. The Bureau also provides standard weights and measures to the states which the states and local government officials use to protect the consumer. The Bureau conducts research in environmental measurements and standards in support of control and regulatory laboratories, including air, water and noise pollution, and radiation safety. Programs in health and safety include the development of clinical Standard Reference Materials, and analysis of the reason for failure of prosthetic devices, automobile and airplane parts, bridges and buildings, pipelines, and other products and structures. Other NBS programs in this area include dental research, mine safety, and lead paint poisoning control. Bureau scientists

also conduct studies to reduce losses from fire and crime, as well as studies involving building design and materials construction, energy production and transmission, and computer science and technology.

One of the most exciting new NBS programs is a Presidential initiative to help improve our understanding of the process of innovation and application of research. The Experimental Technology Incentives Program (ETIP), proposed by the President in his fiscal 1973 budget, seeks to increase the nation's application of technological invention and innovation to such questions as productivity, unemployment, pollution, energy conservation, and unfavorable trade balances. The experiments conducted under the program will systematically explore how the federal government may change its policies, procedures or practices so as to encourage technological change. ETIP activities will involve various elements of the industrial community, professional and trade organizations, educational institutions, agencies of federal, state and local government, and individuals.

NBS has five major technical units in which most of the Bureau's programs are conducted:

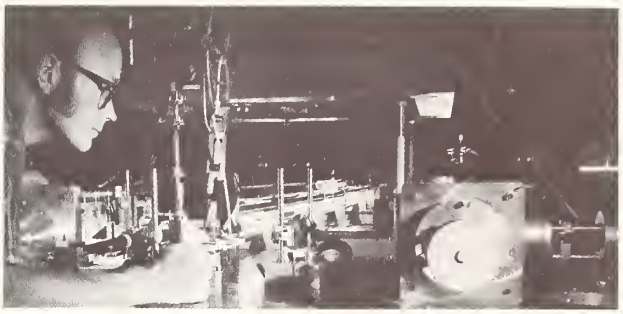
THE INSTITUTE FOR BASIC STANDARDS

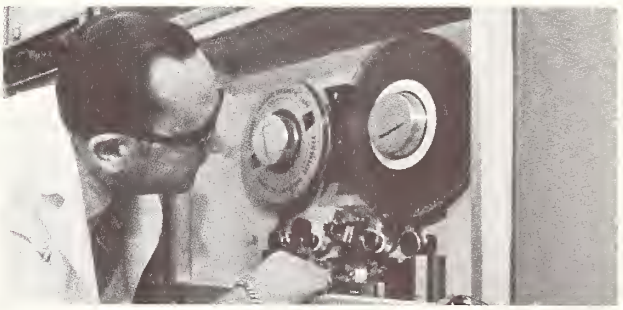
THE INSTITUTE FOR MATERIALS RESEARCH

THE INSTITUTE FOR APPLIED TECHNOLOGY

THE INSTITUTE FOR COMPUTER SCIENCES AND TECHNOLOGY

THE OFFICE OF INFORMATION PROGRAMS





BASIC STANDARDS

The Institute for Basic Standards (IBS) provides the United States' central link to the International System of Measurements (SI), and promotes accurate and uniform physical measurements throughout the nation's scientific, industrial, and commercial communities.

In addition to providing accurate realizations of the base units of the International System (mass, length, time, temperature, electric current, luminous intensity and quantity of matter), NBS must serve the modern-day needs of many varied users. A scientist wishing to know the precise wavelength of his laser, a highway expert needing a reliable check on the skid forces of tires, or an electric company wanting to know the power losses in a huge inductor during its 20 years of service—all depend on physical measurement whose accuracy and reliability are above question. IBS serves each one in its own way, with units, standards and methods of measurement for quantities that run the gamut from very small to very large.

As offshoots of this physical measurements effort, IBS, in its programs:

- Determines data on the properties of matter, needed to make the measurement system more useful.
- Provides a vital supporting role in carrying out measurements and standards for radiation control, as required by the Safety and Health Act of 1968.
- Furnishes measurements for control and abatement of noise.
- Advances cryogenic technology—the engineering use of solid materials and fluids at extremely low temperatures.
- Supplies mathematical services to the entire NBS scientific effort.

MATERIALS RESEARCH

The Institute for Materials Research is concerned with the preparation and purification of technologically important materials; their thorough characterization as to chemical composition, impurity content, and physical structure; the development of new methods for measuring the properties of materials, the generation and evaluation of needed data and information on the properties of materials; and the development of concepts which explain the properties and behavior of materials. This program assists and stimulates industry in the development of new and improved materials and products.

Since 1910 NBS has provided a large variety of Standard Reference Materials (SRM's) whose chemical composition and properties have been accurately determined and certified. These standards are used throughout industry and the scientific community to calibrate and evaluate measurement instruments and test methods. Over 850 different SRM's are currently available. Some current SRM's of particular importance are used for clinical analyses in medicine, air and water pollution abatement, preventive maintenance in transportation systems, and quality control in the manufacture of industrial materials and products. About 30,000 SRM's are sold annually.

APPLIED TECHNOLOGY

The Institute for Applied Technology is concerned with technological development and engineering standards in such areas as building construction, fire research and safety, consumer products performance and safety, electronics, invention and innovation, and systems analysis. The Institute's work, much of it in support of other federal agencies, facilitates the more effective use by both government and industry of such technological standards and developments. The Institute represents the public interest in the development of voluntary engineering standards; develops standards, tests and services to protect the public from hazardous products; and promotes the performance concept for evaluating components, products, and technological processes in such areas as building construction.

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COMPUTER SCIENCES AND TECHNOLOGY

The Institute for Computer Sciences and Technology is the scientific and technical arm of the federal government's automatic data processing management system. Its technical activities result in increased efficiency and effectiveness in the government's use of computers. NBS aids federal management agencies in formulating computer purchasing and management policies. It aids other agencies with specific computer application problems; it develops Federal Information Processing Standards; and it conducts research in computer science and technology. In a broader sense, the Institute's technical activities—which encompass software management, quality control in software production, computer security, computer system performance measurement, computer magnetic storage media measurement and calibration, teleprocessing, and computer networking—are aimed at improving the effectiveness and efficiency of government operations through the use of computers and automation.

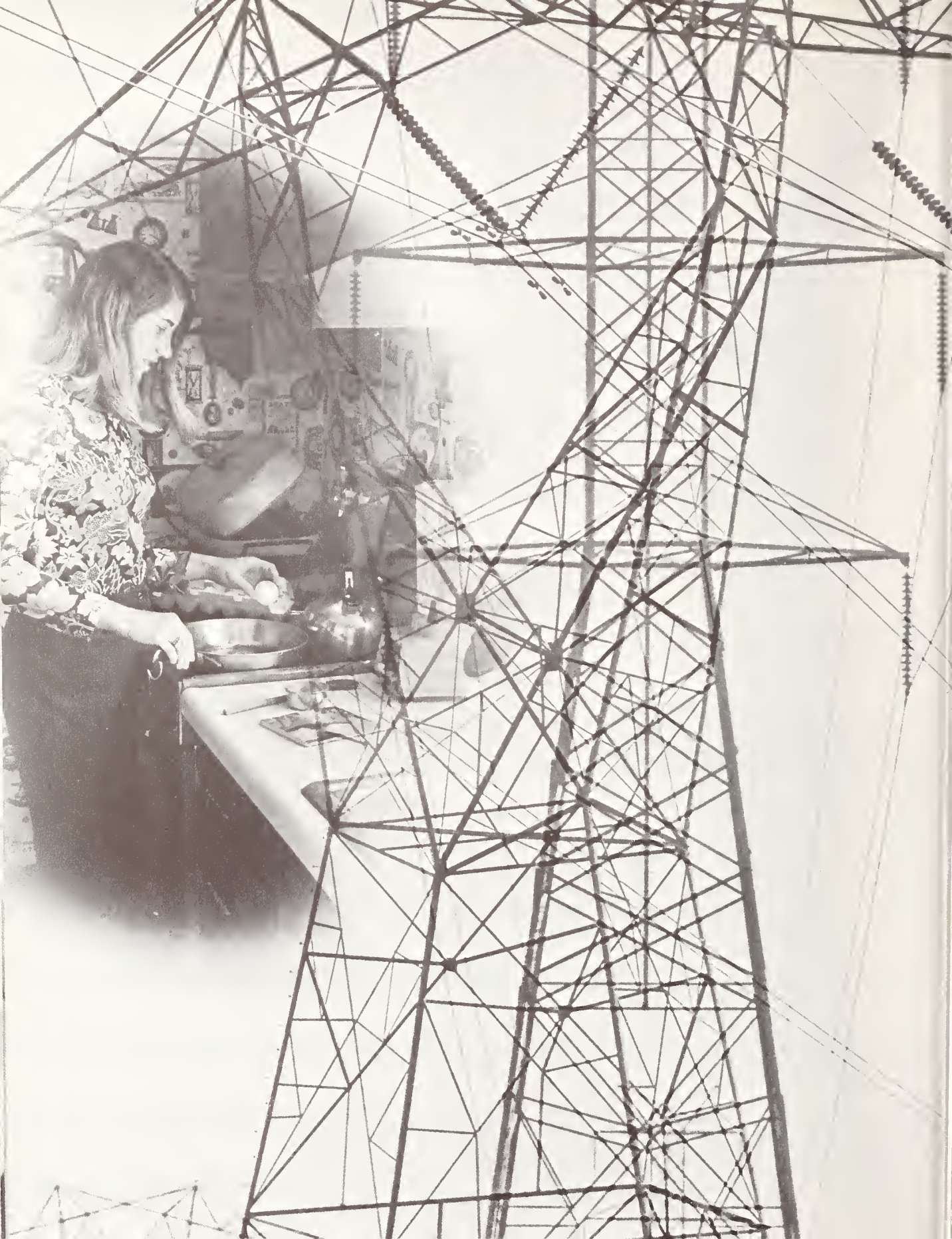
INFORMATION PROGRAMS

The Office of Information Programs seeks to increase the efficiency of information and technology transfer from the Bureau. The three guiding principles of the NBS information program are:

(1) A variety of information from many sources is needed for decision makers at all levels throughout society. Information is therefore produced at many levels and in a variety of formats to reach the user.

(2) The quality of information—that is, its reliability and credibility—is more important than access to great masses of unevaluated information. To promote the availability of reliable information, the National Standard Reference Data program collects, processes, interprets, analyzes, and disseminates technical data for use by the entire community of scientists and engineers. The scope of the program is the entire field of physical and chemical properties of substances.

(3) Information must be appropriately packaged and interpreted for each community of users. New information is constantly being packaged and repackaged in a variety of ways to reach the broadest segment of society.

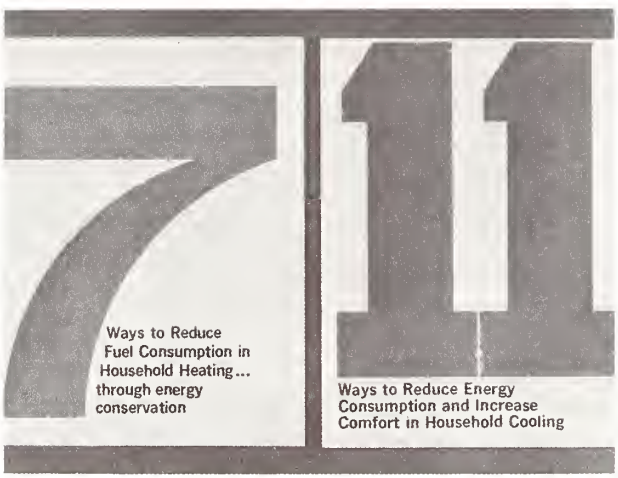


ENERGY

ENERGY

The National Bureau of Standards has a long tradition in several areas of energy research. Since 1901 Bureau scientists and engineers have been working on standards and methods for electrical measurement and control; new sources of energy production; materials for production, storage, and distribution of energy; and methods for energy conservation in industry, in buildings, and in other vital areas.

In the energy message of June 4, 1971, the President directed the Federal Housing Administration (FHA) to upgrade the insulation of FHA-insured houses to reduce heat loss by one-third. NBS helped establish those standards. At the same time, the President also asked his Special Assistant for Consumer Affairs to gather and publish information to help consumers in operating costs of household appliances. The Office


7
Ways to Reduce Fuel Consumption in Household Heating... through energy conservation
11
Ways to Reduce Energy Consumption and Increase Comfort in Household Cooling

NBS bulletins can help save energy in your home.

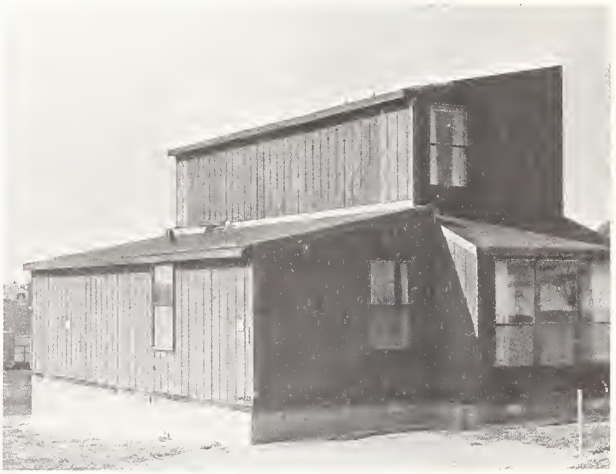
of Consumer Affairs and NBS collaborated on two consumer bulletins: "7 Ways to Reduce Fuel Consumption in Household Heating," and "11 Ways to Reduce Energy Consumption and Increase Comfort in Household Cooling." More than 1.5 million copies of these two bulletins have been distributed. These were but parts of a major effort by the Bureau to find answers to the energy conservation question.

Because of the Bureau's knowledge and experience, the President in 1973 took note of the role of NBS in the nation's energy conservation program during a time of crisis. That activity intensified. But longer-range research programs aimed at making the U.S. an energy-sufficient nation will require support from the Bureau as well. The following highlights feature some activities being undertaken in an effort to help the nation manage and develop its energy resources.

Townhouse Study

New computer techniques developed by NBS showed heating loads calculated by those techniques were lower by 30 percent, much closer to measured values than loads calculated with earlier approaches.

To validate the program, a factory-built townhouse was purchased and installed in the 2,000 cubic meter (70,000 cubic foot) environmental chamber in the NBS Center for Building Technology (CBT). Here, temperatures can be controlled from −45.6°C to +65.5°C (−50°F to +150°F). More than 4.6 kilometers (15,000 feet) of instrument wiring was used and data gathered from 300 stations every 6 minutes around the clock while the weekly living pattern or a family of six was simulated.



Townhouse at NBS site tests energy conservation.

Energy measurements made on the townhouse verified the predictions of the new computer program to within 5 to 10 percent and provided information on how much energy is lost through ceilings, walls, windows and doors. Results confirmed the concepts given in "7 Ways." For example, use of insulation can save 55 percent of the energy required for heating. Single window glass loses 10 times more heat than a well-insulated wall and 5 times more than double glass. Turning the thermostat back 9°F for eight hours overnight saves 11.5 percent of the heating energy when the temperature outdoors is about −6°C (+21°F).

More Building Programs

Much more useful data continues to be generated as the program expands to studies on other buildings. A number of other energy-conservation projects are underway by CBT personnel:

- A 20-year-old frame house on the NBS grounds is being used for "before" and "after" measurements to evaluate the energy savings in current buildings by insulation, caulking, storm windows, and modifications of the heating system (heat pump), lighting and operating practices.
- Design and evaluation criteria for energy conservation in new buildings were drafted at the request of the National Conference of States on Building Codes and Standards in cooperation with several of the leading architectural and engineering professional societies of the country.
- The potential for energy conservation in high-rise apartments using on-site total electric power generation is under study by NBS at the Jersey City Breakthrough site of the Department of Housing and Urban Development. The analytical methods developed in the NBS townhouse study were used to predict the economics of double windows, the need for temperature zoning in high-rise buildings, and the integration of the various load components in eight separate buildings.
- The NBS townhouse has been fitted with a solar energy collector and storage system to develop standard test procedures for solar systems and to develop the technology for integrating in a house such energy-using systems as space heating, water heating and air conditioning.
- The technology of energy conservation in office buildings is being studied and measured in a demonstration office building in Manchester, N.H., in collaboration with the General Services Administration. A parallel development for secondary school buildings is being carried out with the New York City Board of Education under the sponsorship of the National Science Foundation.

Labeling Program for Home Appliances

In 1973, the President directed the Department of Commerce to develop a system of labeling to provide consumers with information on the energy consumption and efficiency of home appliances. Industry support was vigorous. NBS was assigned to work on the project with other federal and state agencies, consumers and retailers.

The first product to be labeled under the energy conservation program is the room air conditioner. Other appliances in the program include refrigerators, home freezers, clothes washers and dryers, ranges and hot water heaters. The key items that appear on labels are: energy consumption, energy efficiency, and energy efficiency compared to similiar products.

Accuracy of the Home Electric Meter

An industrial research associate at NBS funded by the Edison Institute (representing 92 electric utility companies) has conducted a study of the reference-standard watthour meters in the test laboratories of 30 utility companies across the U.S. These reference meters form the basis for acceptance testing of large numbers of house watthour meters, both new and returned from service.

Results indicate that a little over half the laboratories are within 0.05 percent of the assigned NBS value at both unity and 0.5 power factor. Approximately 11 percent showed departures between 0.1 and 0.2 percent, and 11 percent were extremely poor at 0.5 power factor, with discrepancies far in excess of 0.2 percent. NBS has recommended "round-robin" tests for these laboratories and encouraged intercomparisons among the utility laboratories. NBS is now serving as the focus for this effort by providing a measurement assurance type program through shippable transport standards. This type of interaction will improve metering accuracy and uniformity on a nation-wide basis to the mutual benefit of both buyer and seller.

Coal Research

NBS, with the support of the Office of Coal Research of the Department of the Interior, has undertaken a cooperative program aimed at providing needed data and measurements on the properties of materials used in planned coal fired magnetohydrodynamic (MHD) power generating systems. NBS is acquiring data needed to help overcome problems associated with high temperature vaporization of refractory materials, electrical conductivity of MHD electrodes and insulating materials, viscosity of coal slags and coal slag-seed reactivity as well as seed-electrode and seed-insulator reactions.

A MHD generator is a type of expansion engine in which hot, partially ionized gases are forced through a magnetic field, thus generating an electric current collected by electrodes lining the chamber walls. It is a more efficient way to generate electricity than conventional generating systems, particularly if exhaust gases from the MHD expansion chamber are used to operate a steam turbine. The proposed MHD systems are expected to be as much as 25 percent more efficient than conventional or nuclear power plants. Furthermore, MHD is potentially a valuable method for burning high sulfur content coal since the sulfur combines with ionized gases in the expansion chamber and can be removed early.

Fuel Gas

Numerical values for combustion energies for 54 hydrocarbons and other constituents of natural gas were converted to tables suitable for use in the gaseous fuel industry by NBS scientists. The data were obtained from compilations prepared in the NBS Chemical Thermodynamic Data Center for pure substances in standard thermodynamic states. They were reduced to a form directly applicable in the field, i.e., the data are given for reference temperatures and pressures used in the gas fuel industry, on a volumetric rather than a mass basis, and for conditions of water saturation required in the industry. Tables of conversion factors were also provided. These data will be used by public utilities and other large users of fuel gas in estimating heating values of fuel mixtures in situations in which actual measurement of the heating value is important. A standard procedure for this calculation is being prepared, and the data will be used in this calculation.

Natural Gas Properties

Liquefied natural gas (LNG) is assuming increasing importance in the energy marketplace. Lack of thermophysical properties data for LNG and its components has hampered equitable transfer between buyer and seller and engineering design of new liquefaction plants, cryogenic tanker ships, and import terminals. NBS is producing thermophysical data required to meet these needs. The American Gas Association and a consortium of 74 American and international natural gas companies are funding the studies at Boulder.

In one project, measurements of vapor pressures, compressibilities, dielectric constants, and specific heats have been performed on pure compressed and liquefied methane at temperatures down to solidification. A second project is to develop a magnetic densimeter and to accumulate accurate data for calculating the densities of mixtures of components of LNG.

Submarine Tankers for Alaska Oil

At the request of the Department of Commerce's Maritime Administration (MARAD), NBS conducted a study of a proposal to use submarines to transport oil from Alaska to East Coast U.S. ports. The NBS study was to identify governmental programs which have interests in common with the proposed MARAD concepts. NBS identified a total of 17 other programs in seven other agencies, representing large potential resources for funding of a joint effort with MARAD.

Electric Power Research

NBS is cooperating with the Electric Power Research Institute to calibrate coupling-capacitor-voltage-transformers. These devices are used for energy flow metering and power line carrier coupling in extra-high voltage electric power substations. They will be similarly used in ultra-high voltage installations as these become more prevalent with the growing demand for energy. Some measure of the significance of this project is provided by the fact that an uncorrected error of 0.5 percent in the metering of energy flow at an intertie represents an inequity of more than $500,000 annually.

Nuclear Energy Advances

The production of electric power from nuclear reactors is probably the most promising hope for this energy-hungry world. Studies at NBS are helping advance low cost nuclear energy.

Nuclear generating station provides enough power for half a million people.

VERY LOW ENERGY PHOTOFISSION. Power is being produced in many countries today with "thermal neutron" reactors, and a fast neutron "breeder" demonstration reactor is scheduled for completion early in the next decade. Yet the fundamental process of fission is not well understood. Recently a double-barrier model of fission was introduced which represents a considerable improvement in our understanding of the fission process.

The NBS Center for Radiation Research, using techniques with sensitivity improved by a factor of about 10,000 over previous methods, has found measurable photofission and obtained information about the shapes of the one-barrier and two-barrier models. This information is important for the energy-producing fissionable nuclides. It can be used to predict delayed neutron yields from fission—which partly determine the dynamics of nuclear reactor behavior—and to understand photofission occurring in addition to the neutron-induced fission in nuclear reactors.

ATOMIC FUEL SURVEILLANCE. National and international atomic energy organizations are responsible for the control and safekeeping of fissionable material. Installations using or processing fissionable materials must be monitored to ensure that incoming and outgoing fuel or spent fuel is accounted for securely. With funding from the Atomic Energy Commission (AEC), the Arms Control and Disarmament Agency, and the International Atomic Energy Agency, NBS has developed a photographic intrusion monitor for surveillance of reactor fuel bays or similar installations. Combining television and lapse-time photographic techniques, the instrumentation provides photographs on demand whenever one or more points of interest in a field are altered or obscured. The system may eventually be incorporated in international standard procedures.

"PEACE PIPE" FOR BREEDER TECHNOLOGY. NBS developed an instrument—dubbed the "peace pipe" because of its shape—for measuring the fission rates in fuels to be used in the fast breeder reactor programs of the AEC. Uncertainties in measurements of these rates in the past resulted in over-designed and therefore over-costly reactor cores. A series of accurate calibrations and intercomparisons was carried out with the new instrument among laboratories concerned with fission rate measurements in reactor fuels. The interlaboratory effort has cut measurement uncertainties in half and resulted in subsequent savings, since one loading of these fuels will cost some tens of millions of dollars.

ATOMIC DATA. Scientists at NBS are working on providing basic atomic radiation data essential to the diagnostics needed in thermonuclear fusion research. One particular study is to determine atomic transition probabilities needed for measurements of plasma temperature and impurity concentrations. The need for these data exists for those elements found as impurities in the deuterium fuel (e.g., nitrogen, carbon, and oxygen) as well as those elements used in the construction of the plasma vessels (e.g., iron, tungsten, titanium, and molybdenum).

The experimental as well as theoretical data for these calculations are as a rule still rather inaccurate, and their uncertainties are difficult to estimate. It is, therefore, desirable to tie the experimental and theoretical data together to have an independent check on their accuracy and consistency. Such a connection, found at NBS, established that systematic trends exist for the atomic properties along isoelectronic sequences. These findings are now put to good use to tie the theoretical and experimental data together and to provide reliable new data for the highly ionized species encountered in fusion machines by interpolating between existing data. About 100 such systematic trends have been now firmly established.

ENVIRONMENT

ENVIRONMENT

Through the Federal Clean Air Act, the Water Pollution Control Act and the National Environmental Protection Act, Congress issued mandates for protecting our environment from dangerous contamination.

This national effort to protect the air and water environments is primarily one of enforcement of regulations and control. The National Bureau of Standards, by providing the technical basis for such regulations and controls, is playing an increasingly important role in assisting the nation to achieve the goal of pollution abatement.

If there were no accurate or generally accepted methods of pollution measurement and reference standards, the Environmental Protection Agency (EPA) would have difficulty administering its regulatory programs. At the same time, industry could not comply economically with regulations without a firm basis for measurement. NBS, working as an impartial third party to develop measurement methods and standards, aims to make it possible to protect the public health at minimum cost.

The Bureau works in support of the nation's pollution abatement programs by providing:

- Standards for measurement (both standards of methodology and Standard Reference Materials (SRM's).
- Improved measurement techniques and instruments.
- Calibration of measurement systems.
- Scientific information and data.

In 1970, NBS created the Measures for Air Quality (MAQ) Program in response to national needs. The program now encompasses water pollution measurement and standards activities as well, and work is conducted in several organizational units throughout the Bureau.

Automotive Emissions Analysis

In 1972, a meeting jointly sponsored by the EPA and NBS was held to discuss the need for standard reference gases for mobile-source emission analysis. Participants from the automobile industry, EPA and the specialty gas manufacturers said standards would be essential for monitoring compliance with automotive emission laws. One result of this meeting was the recommendation that NBS prepare several concentrations of four gas mixtures as a part of the SRM program. The mixtures are: propane in air, carbon dioxide in nitrogen, carbon monoxide in nitrogen, and nitric oxide in nitrogen.

Preparing Standard Reference Materials for auto emissions.

These standard reference gases are not daily working standards, but rather "primary" standards to be used in the calibration of daily working standards obtained from commercial sources. They are also used by gas manufacturers to help control the quality of the working standards during processing. Thus, there will be a traceability of all gas standards used in mobile-source emission analysis back to NBS, the central reference laboratory.

Detecting Particulates In Air

In many areas of environmental control, especially occupational health and safety, it is important to be able to measure particulate matter in air almost instantly, like lung-interacting particulates smaller than 5 μm. The properties of most interest are the total number, size distribution, chemical composition and shape.

A light scattering instrument has been developed at NBS which can determine, almost immediately, the size distribution and total number of particles in air over the size range 0.05 μm to 5 μm. Particle size measurements are made with only a minimum amount of error from the index of refraction of the particle, a major source of error in other types of light scattering instruments. In addition, a technique has been developed to classify the particles chemically (e.g., carbon-like, metallic).

New Pollution Monitor

A monitor developed at NBS to detect sulfur dioxide (SO_2) is now being made commercially available. The detector response is rapid, continuous, specific to SO_2, and linear over many orders of magnitude of SO_2 concentrations. The device will be mainly used for smoke stack gas monitoring. About 80 million tons of sulfur dioxide are released into the atmosphere each year mainly through the burning of sulfur bearing coal and

oil and through such industrial processes as oil and metal refining. Concentrations as low as a few parts per million can cause breathing difficulty, kill plants, leach limestone and degrade paper and leather.

Fuels In Motor Vehicles

NBS has examined the performance of several motor vehicles run on gaseous fuels rather than gasoline. The operations and exhaust emission characteristics of ½- and 1-ton trucks operated on three different fuels—gasoline, compressed natural gas (CNG), and liquefied petroleum gas (LPG)—were determined for the U.S. Postal Service (USPS). Emissions of hydrocarbons (HC), carbon monoxide (CO), and the oxides of nitrogen (NO_2) were monitored on USPS trucks under a range of environmental and load conditions. Three dual-fuel systems were analyzed and recommendations made on the best settings for spark firing and fuel regulation (for CNG and LPG) to minimize pollutants and to produce acceptable power.

CNG-powered 1-ton Postal Service truck in NBS environmental chamber.

POLLUTANT LEVELS—HALF/TON TRUCK

POLLUTANT	GASOLINE	FUEL CNG	LPG
NO_2 (ppm)	1700	300	500
HC (ppm)	190	50	190
CO (%)	1.00	0.10	0.13

The federal government operates between 300,000 and 400,000 vehicles—potential candidates for gaseous fuels. In October, 1969, the General Services Administration (GSA) launched the government's first fleet of CNG-power test vehicles; 12 vehicles in the Los Angeles area were converted to a CNG-gasoline dual-fuel system. Today more than 1,500 GSA vehicles operate with such a system. In addition, the Postal Service is operating a fleet of approximately 50 vehicles in the same manner and is considering expansion of their operation.

Fossil Fuel Standards

Emissions from the burning of fossil fuels are a possible major source of trace toxic element contamination. A joint program between EPA and NBS resulted in the characterization of a sample of coal and of coal fly ash for use as Standard Reference Materials. The content of 14 trace elements has been determined in the coal and 10 trace elements in the fly ash. These materials will help laboratories within the EPA as well as private power companies and others in standardization of their analytical instruments and in a regular quality assurance program.

Toxic Trace Industrial Materials

Under the sponsorship of EPA's Office of Research and Monitoring, Bureau chemists have made a critical survey of available methods for detecting a variety of important industrial toxic materials in trace quantities.

They have looked at the capabilities and costs of such analytical tools as nuclear methods, spark source mass spectrometry, x-ray fluorescence and electron microprobe spectrometry, atomic absorption spectrometry, absorption spectrophotometry, atomic emission spectroscopy, voltametry and potentiometry. These techniques can be used in a wide variety of compositional analyses, such as determining traces (less than 100 parts per million) of mercury, beryllium, cadmium and many other industrial materials in fly ash, coal, oil, ores, minerals and so forth. The results will aid scientists with a specific problem in picking the proper analytical tools.

Mercury Analysis

A technique has been developed at NBS to identify and analyze mercury and volatile organo-mercury compounds produced by microorganisms from the bottom sediments of Chesapeake Bay. The system can detect mercury compounds at natural levels in one milliliter of air. Separating specific compounds of mercury yields insights into environmental processes that are not apparent from procedures that merely analyze for total mercury present.

Using the technique, the Chesapeake Bay microorganisms have been shown to convert inorganic mercury both to the element and to methylmercury. Studies are now under way to measure rates of these mercury-conversion reactions by several different bacteria.

Taking bottom sediment samples from Chesapeake Bay.

Water Sampling

Bureau chemists have also developed a "non-contaminating" water sampler and preconcentration methods to allow the accurate determination of heavy metals at the part-per-million and part-per-billion concentration levels in water. Plastic materials that can be cleaned vigorously are the only surfaces with which the samples come in contact. A fast-frozen sample can be in dry ice storage within 10 minutes after it is taken from its source. Preconcentration of the sample is performed by freeze-drying. NBS is using the Patuxent River and the Chesapeake Bay as test areas for demonstrating the usefulness of these methods.

Salmon Fisheries To Benefit

The state of Washington, under the sponsorship of the National Marine Fisheries Service, has started two NBS projects for the large-scale mathematical modeling of the Pacific Coast salmon fisheries. Under study will be such features as the effects of fishery management policies, of hatchery resource allocations, and of the timing, size and release of different fish species on the economic output of the fisheries.

This project, conducted partially under the aegis of Public Law 309 (federal-state revenue sharing), has been undertaken as an example of large-scale modeling and analysis in order to improve management efficiency in an area whose annual yield to the state of Washington alone is over $100 million, when both commercial and sport fishing are considered.

Nuclear Pollution

Tritium in water and carbon-14 in carbon dioxide have always been produced by natural processes. But the environmental inventory of each is increasing, due to man's activities. Added to these are long-lived krypton-85, which is now present in the environment as a result of various nuclear fission activities, and shorter lived radioactive noble gases. By the year 2060, the world may closely approach the maximum permissible concentration of krypton-85 in air.

Scientists in the Center for Radiation Research have developed a fast and accurate technique for calibrating monitors for measuring radioactive argon-41 effluent being expelled from the stack of a nuclear reactor. Argon-41 is one of the most active radioisotopes released to the environment. The NBS gas counting system consists of one set of stainless steel and one set of copper length-compensated counters. Count-rate data at different cathode voltages and gas pressures are fed simultaneously from all six counters into an on-line computer used as a multichannnel pulse-height analyzer.

As an additional service to the operators of nuclear reactors, and to other concerns monitoring environmental radioactivity in the neighborhood of power reactors, NBS has prepared and made available as Standard Reference Materials several types of mixed samples of typical reactor gamma-ray-emitting nuclides. This service was started early in 1972 and has received enthusiastic acceptance from users. A special mixture of radio-nuclides was prepared for the AEC Health Standards Laboratory, which intends to use it as a standard solution for that agency's traceability study with the state monitoring laboratories.

Noise Pollution Progress

The Bureau's noise pollution program is making significant contributions to the understanding and control of noise and its impact on man. Among many noteworthy achievements are those in conjunction with the Department of Transportation (DoT) on truck noise and the Department of Housing and Urban Development (HUD) on noise around urban residential neighborhoods.

To fill the need for valid data on noise levels inside trucks, the Bureau made an extensive series of measurements on typical modern trucks. These measurements, made with the cooperation of the American Trucking Association, may lead to development by

Measuring noise-levels in truck cab

DoT of a simple, single interior noise measurement that correlates well with over-the-road measurements and may be used in tests to insure adequate driver protection.

Fifteen trucks—14 tractor trailers and one delivery van—were used as test vehicles. The data showed that in many cases the noise level in the cab exceeded 90 db(A), the limit set under the authority of the Occupational Safety and Health Act for noise during an 8-hour work day.

NBS also developed prototype instrumentation to measure relevant noise parameters against HUD standards for publicly-funded housing. The instrumentation consists of a "monitor" left at the desired location for at least a 24-hour period, and a "reader" which interrogates the monitor to extract the information stored in its memory. The monitor is a self-contained battery-operated unit designed to be mounted at an elevated position at the test site. It includes a microphone and weather screen, together with an electronic package which measures and records the time intervals over which an environmental noise level greater than one of six specified amounts is exceeded. These factors, together with time and wind velocity, indicate how many times and for how long 55 db(A) level of noise was exceeded, and how many minutes 45 db(A) level was exceeded between 11p.m. and 7 a.m., providing detailed criteria on whether the location is suitable to use for sleeping quarters.

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HEALTH AND SAFETY

HEALTH AND SAFETY

In a modern technological society, one of the most important applications of the physical and chemical sciences is in assuring the health and safety of citizens. The need for measurement accuracy and standards in clinical dental care is recognized at NBS through active programs in such areas as dental materials research, clinical measurements and standards, medical thermometry and dosimetry. Contributing significantly to the safety of the individual are investigations of the reasons behind failures of structures, airplane crashes, building fires and other disasters and subsequent recommendations for avoiding future failures. NBS serves to provide both a measurement and a data base for these types of investigations.

In addition, law enforcement receives major attention at the Bureau through a wide range of projects aimed at developing performance standards in areas such as communications equipment, metal weapon detectors, burglary alarms and other aspects of physical security.

HEALTH

TV Captions For The Hearing-Impaired

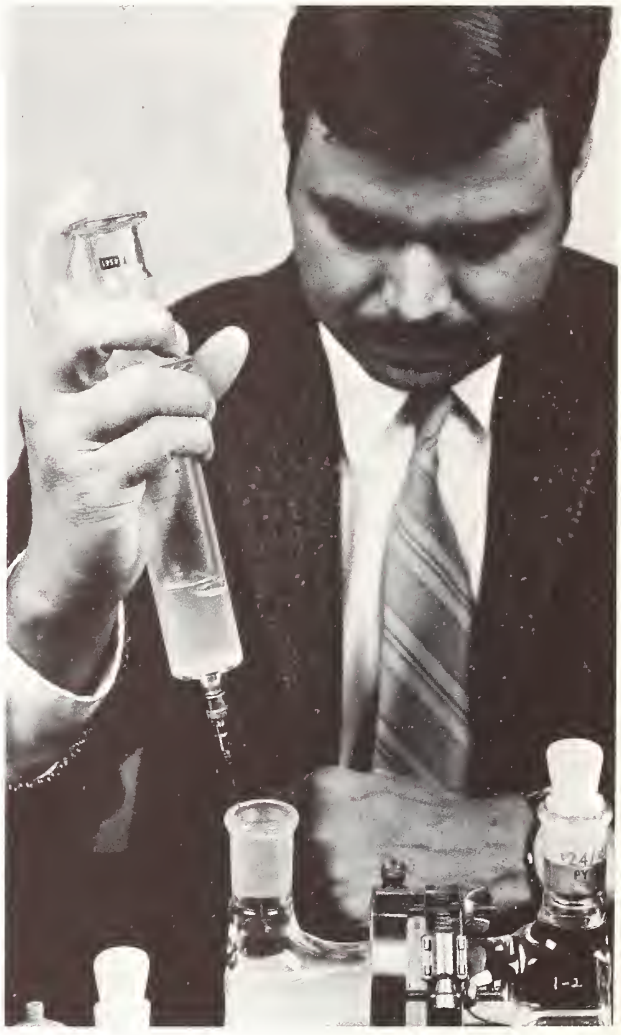
Television captions for the deaf, a feature of the NBS TV-Time System, were accepted for test on the Public Broadcasting System in 1974. The Department of Health, Education, and Welfare (HEW) funded the project, which will enable many hearing-impaired people to evaluate the NBS system under operational conditions. Reactions and suggestions of deaf viewers have been extremely positive on limited commercial showings.

Lead Paint Poisoning

NBS staff assisted the Department of Housing and Urban Development in determining the nature and extent of lead paint poisoning in the United States by developing analytical techniques for the detection of lead in paint and for the control of the lead paint hazard in housing.

New Dental Materials

Many Americans have fillings in their teeth which last twice as long and have superior properties as a result of new materials developed at NBS. The materials, called composites, match the appearance of the teeth and last longer than silicate cement, saving on replacements. Dentists are now placing some 34,000 composite fillings daily—about equal to the number of silicate fillings—and the use of the new materials is growing rapidly. Today's commercially available composites are based upon prototype materials developed at the Bureau. The benefits to patients typify over 50 years of NBS contributions to progress in dentistry through measurement and materials science and technology. For example, the high speed turbine drills, now almost standard equipment in the dentist's office, came from NBS research.



Preparing diffusion cell in study of the process of tooth decay.

New Theory Of Tooth Decay

In research sponsored by the National Institute of Dental Research, NBS developed a theory of tooth decay that could lead to new methods for prevention of cavities. In a different approach to the problem, NBS-American Dental Association researchers theorized that the tooth surface allows calcium to leave the tooth and hydrogen to enter. This exchange increases the acidity within the tooth, causing more tooth mineral to dissolve and accelerating the diffusion of calcium. If the theory proves correct, it will simplify the search for new decay preventives.

Clinical Measurements and Laboratories

In the U.S., there are at least 15,000 clinical laboratories which analyze billions of human serum, urine and tissue specimens each year. The performance of some clinical laboratories is monitored by various accreditation and licensing programs through inspection and/or proficiency testing. Many laboratories, however, are subject to little or no control. In order to obtain comparable data on laboratory measurement performance, the Division of Health Evaluation of HEW asked NBS to develop and implement a comprehensive national survey of clinical laboratories. As a result of the NBS study, HEW is now in a better position to assess objectively the value of proficiency testing and its impact on laboratory capability. The information is an aid to designing a more proficient testing program.

In another NBS project, Standard Reference Materials (SRM's) and Reference Methods are developed to improve accuracy in clinical measurements. NBS has prepared 20 clinical SRM's and one Reference Method (Calcium), and more are in preparation by NBS and others. For example, the cholesterol SRM produced in 1967 provided clinical laboratories a means to evaluate their measurements, and cholesterol producers a means to improve their quality control. The need to improve cholesterol measurement techniques has also been recognized. Thus, NBS is conducting studies to identify and eliminate the factors that adversely affect the accuracy of these measurements.

Blood Banking Cost Analysis

At the request of HEW, NBS conducted a study of the national blood banking system to project the cost impact and health risk associated with changes to the current system of blood banking from legislative, technological and operational policies.

Presently, three federal agencies, four national organizations and at least eight states impose regulations on the blood industry. The nature of the regulatory controls, their degree of coverage and their manner of enforcement differ widely.

The NBS report included a cost analysis of the current blood banking system and nine alternative system structures. The NBS study provided HEW with a clear picture of the costs and benefits associated with each of the alternative programs, thereby enabling HEW to develop a proposal for a new national blood banking program based on objective quantified information.

Microcalorimetry

The feasibility of using microcalorimetry—measuring minute quantities of heat—as a procedure for making clinical laboratory tests was demonstrated in a program sponsored in part by the National Institutes of Health. Because biological processes and chemical reactions evolve heat, the sensing of this heat can be used as an indication of the presence of specific substances, or can be used to characterize metabolic and other biological processes. The microcalorimeter is sensitive enough to observe metabolic processes in very small amounts of living tissue. The potential applicability of the technique to the identification of bacteria and to the study of the growth processes and the effects of chemical and physical agents on bacteria has also been demonstrated.

Injecting sample for test in microcalorimeter.

Sanitary Conditions Of Migrant Labor Camps

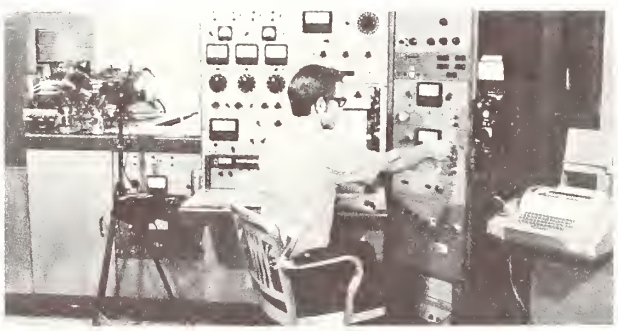
At the request of HEW's Community Health Service (CHS), NBS devised a system for conducting a field assessment of the sanitary conditions of migrant housing. The NBS survey team developed a sampling plan for field surveys, constructed a questionnaire designed to allow laymen to evaluate sanitary conditions in migrant camps, and performed on-site field visits to camps in California, Texas, Florida, New York, Michigan, Maryland, Virginia and New Jersey. The NBS survey team improved the survey procedures which CHS field-tested in order to conduct a valid national survey of the sanitary conditions of migrant labor camps.

Connective Tissues

Scientific opinion is divided on the question of whether the essential water in such biological materials as tissues and cells is physically more like a liquid or a solid. The question has considerable bearing, for example, on the way in which ions are transported through cell membranes, and on the reasons why some tissues are damaged by freezing while others are not. NBS is using nuclear magnetic resonance (NMR) to study the structure and mobility of water and salt-water solutions in contact with the fibrous protein collagen, which is the chief component of connective tissues in the body. Many of the important physical properties of collagen, such as flexibility, swelling, and melting temperature, are greatly affected by its moisture and salt content.

Trace Metals In Blood

Techniques for analysis of lead, iron, chromium and other metallic elements in whole blood or its various components have been developed at NBS and applied to actual samples of both human and animal blood and blood serum. The methods show particular promise to



Using mass spectrometer for analysing trace metals in blood.

produce, evaluate and control SRM's and to check on clinical laboratory procedures. They may also be used for research projects involving, for example, the accurate determination of the amount of iron in hemoglobin.

Trace Elements In Urine

Urine is widely used in occupational health monitor programs because it is a good indicator for concentrations of many trace metals and because samples can be readily obtained. Under sponsorship of the National Institute of Occupational Safety and Health (NIOSH), NBS tested samples of freeze-dried urine for five trace metals at two concentration levels—"normal" and "elevated"—for use as test standards in NIOSH laboratories. The metals determined were nickel, chromium, arsenic, selenium and copper. Three additional stabilized liquid samples at "blank," "normal," and "elevated" concentrations were prepared and analyzed for inorganic mercury determinations. These materials will be used as check and reference standards in NIOSH-administered laboratories.

Industrial Hygiene Analysis

A wide variety of analytical measurements must be made to protect millions of workers and to fulfill the requirements of the Occupational Safety and Health Act of 1970. Industrial atmospheres must be monitored for toxic or hazardous gases, vapors and particulates. Clinical examinations of blood and urine are also required. Several hundred toxic or hazardous materials have already been identified or are under investigation, and the list will surely grow.

NBS, under the sponsorship of NIOSH, is providing analytical reference standards, calibration procedures and method-evaluation studies. Experimental work is underway to develop and produce gas calibration systems, filters containing hazardous inorganic substances, analytical standards for organic solvent vapor analysis, and blood and urine reference materials.

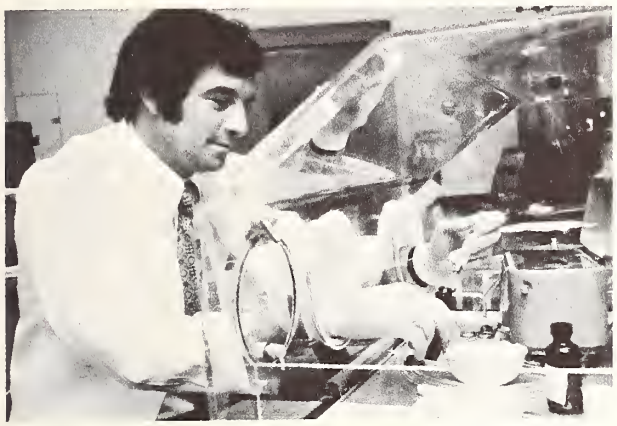
Respirable Dust

The present occupational safety and health standards accepted by the Department of Labor define threshold limit values (TLV) for a great many substances, among which are the crystalline forms of silica in dust. In cooperation with NIOSH, NBS has investigated the usefulness and limitations of x-ray diffraction as an analytical tool for the analysis of very small quantities of quartz. The investigation showed that one currently used technique under ideal circumstances can readily and reliably detect quartz in concentrations about one third of the present TLV requirements.

Hip Implant Cement

Scientists of NBS and an orthopedic surgeon of the George Washington University Medical Center have characterized the "cement" used in orthopedic surgery to stabilize total hip implants. Emphasis has been on determination of the physical, chemical and me-

chanical properties of the poly(methyl methacrylate)-based cement as it is prepared and used in the surgical procedure. Such materials used in total hip joint replacement and neurosurgical applications can help industry and the medical profession to deliver improved health care to the patient.



Mixing cement for hip implants under controlled conditions in incubator.

Biological Implant Materials

NBS has completed a one-year investigation of metallurgical implants in cooperation with the National Institute of Arthritis, Metabolism and Digestive Diseases. The project was an evaluation of the current status of metallic materials in orthopedics. The final report covers current use of metallic orthopedics devices, comparing different alloys with their applications, and pointing out both successful and problem areas. An implant materials literature information file being maintained at NBS contains over 200 technical articles concerned with metallic orthopedic implant materials. Data on strength, corrosion resistance, tissue tolerance, and other significant factors, are available on various metals.

Medical Ultrasound Standards

NBS Boulder has made a pioneering intercomparison of ultrasonic power measurement techniques with the Bureau of Radiological Health (BRH) in Rockville, Maryland. The results dramatically established the nation's first national basis for precision measurement in support of ultrasound in medicine. Very high frequency sound (1-20 MHz) is used extensively in medicine for both diagnostic and therapeutic purposes. It provides visual information about structures in the body that can be obtained in no other way. Its use has been severely hampered by an inability to measure the transmitted ultrasound power levels with a repeatability of better than 20 percent. Very few absolute measurements have been made.

In response to a request from BRH, three BRH methods for measuring ultrasonic power were compared against two NBS-owned and calibrated ultrasonic transducers. The results of the intercomparison showed that the best BRH instrument, a calorimeter, was within 5 percent of the NBS power values, which themselves have an estimated accuracy of 5 percent.

Calibration System For Radiation Therapy

More than one-half million persons receive radiation therapy for cancer each year in the United States. There is a clear need for the national standards of absorbed dose. With the support of the National Cancer Institute, NBS is developing an absorbed-dose calibration system to provide the necessary traceability for high-energy electron and proton beams for radiation therapy of cancer. Provisional absorbed-dose calibrations are supplied to some of the larger cancer centers. The service will be rapidly adopted when it is fully available, and will make a significant contribution to high-energy radiation therapy by providing that uniformity of measurement essential to precise control of dose to the patient.

SAFETY

Fire Loads In Buildings

Under the sponsorship of the General Services Administration (GSA), the Building Research Advisory Board of the National Academy of Sciences/National Academy of Engineering, contracted with NBS to conduct a pilot survey of the combustible contents of buildings. A survey of 10,000 rooms chosen from 100 buildings representative of all U.S. office buildings will assist GSA in updating its building design requirements by determining the amounts of combustible contents in the buildings, and the changes in the use of buildings when new equipment and furniture are added.

Disaster Mitigation

Managua, Nicaragua, December, 1972.

NBS furnished technical advice and engineering support to HUD on the heating capacity and safety of 16,000 mobile homes provided families made homeless by Hurricane Agnes. At the request of the Agency for International Development (AID), NBS staff helped assess the rehabilitation prospects of buildings damaged by an earthquake in Managua, Nicaragua. NBS engineers are serving on a team to review new building design standards and regulatory procedures in Managua and also in Mexico City, Mexico. NBS is also assisting in AID-sponsored studies aimed at strengthening the wind resistance of low-cost buildings in several developing countries.

Detecting Smoke and Toxic Gases

As many as two out of three fire victims die not from burns but from smoke and toxic gases. To learn about how smoke travels through buildings, NBS is using an inert tracer gas, SF_6 (sulfur hexafluoride), to simulate smoke movement. With SF_6, tests can be performed within a building such as a hospital without disturbing the occupants of the building.

Radiation Meter Wins National Award

A new radiation meter developed at NBS Boulder received a "Top 100" new products award of the year by *Industrial Research Magazine*. The meter is used to measure the energy density of electromagnetic fields surrounding radars, microwave ovens and other electronic equipment. It is of use to health physicists concerned with radiation hazards to humans and other living things, and to electronic equipment; to biological researchers measuring the radiation dose received by subjects in experiments, and to trouble shoot electronic equipment for radiation leakage.

Using new meter to detect hazardous radiation from equipment.

Law Enforcement

NBS carries on a number of activities for the Department of Justice's National Institute of Law Enforcement and Criminal Justice (NILECJ). These activities are coordinated by the NBS Law Enforcement Standards Laboratory. Some examples:

HEARING PROTECTORS. The Department of Justice is concerned about the amount of noise to which law enforcement officials are exposed on firing ranges, since loud noises can cause permanent as well as temporary hearing loss. NILECJ requested NBS to develop a standard for hearing protectors for use on the ranges. Although the standard was promulgated by Justice to fulfill the needs of law enforcement officers, the standard can be used to conserve the hearing of people in other areas, such as foundries, where workers are exposed to loud, sustained or impulse noises.

BURGLAR ALARMS. NBS investigation of burglar alarm systems and components led to the development of standards, user guides and the basic information needed by consumers who wish to use these devices. Two standards were prepared—one for magnetic switches and one for mechanically actuated switches for burglar alarm systems. These standards include performance requirements and test methods with emphasis on the reliability and false alarm susceptibility of the devices.

LAW ENFORCEMENT COMMUNICATIONS EQUIPMENT. Law enforcement agencies need effective communications to protect the public. NBS is evaluating specialized law enforcement communications equipment in order to prepare four documents: A standard for mobile radio antennae, a report on batteries, a report on battery chargers and charging techniques, and a compilation of communications terms and definitions.

METAL WEAPON DETECTORS. NBS developed a standard for walkthrough metal detectors used in weapons detection. These devices are used in air travel and can also be used to protect the public in such places as courtrooms and other public buildings. They can detect objects such as guns, knives and razor blades hidden on the body.

NIGHT VISION DEVICES. Night vision devices are used by law enforcement officials to observe and photograph activities which would otherwise be concealed by darkness. NBS developed test procedures to evaluate factors influencing the image quality of night vision devices such as optical gain stability, image brightness and brightness uniformity and light induced background, contrast and flare. A report on test procedures for night vision devices and a report on image quality criteria for passive night vision devices were prepared.

GUNSHOT RESIDUE ANALYSIS. Neutron activation analysis is now often used in determining traces of barium and antimony on the hands of persons suspected of having recently fired a handgun. NBS has developed a rapid "aerosol" technique for acquiring samples from the hands. A simplified chemical processing procedure for isolating the barium and antimony has been established. The project also involves a study of the reliability of gunshot residue analysis as a function of time between firing and sampling.

Testing for residue left from fired gun.

INTRUSION DETECTOR. A thermal device sensitive enough to detect a person entering a room at more than 15.2 meters (50 feet) by sensing body heat was developed at NBS. It may also be used to sense changes in temperature of equipment or other objects that may signal malfunction or potential fire hazard. The plastic sensor at the heart of the scanning detector is one result of research into the electromechanical properties of polymers. The sensors respond to strain produced by change of temperature or by mechanical force.

PHYSICAL SECURITY STANDARDS. NBS is studying data on the character and force applied on doors and windows in burglaries in order to develop security levels for different door and window assemblies. The work includes publication of performance levels for physical security and guidelines for upgrading security of homes and small businesses.

CONSUMER PROTECTION

CONSUMER PROTECTION

NBS has long been involved in aiding industry to make measurements of the properties of manufactured products. This type of measurement technology is essential to all manufacturing processes and to quality control. Today, more emphasis than ever before is placed on one product aspect: safety. The Consumer Product Safety Act, passed by Congress in October, 1972, authorized establishment of the Consumer Product Safety Commission (CPSC), with responsibility for reducing the accident toll. The legislation specifically directed the commission to utilize to the maximum extent possible resources and facilities of the National Bureau of Standards in its efforts.

In addition to the mandatory safety standards which the CPSC enforces and for which NBS provides much of the technical backup, many manufacturers are taking individual responsibility for ensuring the safety of their products. For both mandatory and voluntary safety efforts, it is necessary to be able to measure electrical voltages, temperatures, sharpness and many other quantities, not just in the laboratory, but under the more uncontrolled conditions of the production line and of the marketplace. NBS is providing the technical bases for many of these difficult measurements.

Consumer Product Safety Center

Some 20 million Americans are injured in the home each year as a result of incidents related to consumer products. Of these, 110,000 are permanently disabled and 30,000 are killed. NBS established a Center for Consumer Product Safety to help the CPSC improve safety aspects of a wide variety of consumer products, including toys, electrical appliances and textile products. Work at the center will provide the technical bases for standards that will be applied to potentially hazardous consumer goods.

INJURIES AND PRODUCTS. NBS investigated a series of injuries and the products involved to develop methods for defining, identifying and measuring sharp points and the injury potential of various projectiles. The flammability of sleeping bags, slumber bags and play tents was studied under real-life conditions. An analysis was conducted of the injury potential of objects with which a falling person comes in contact. A study of the tractive properties of children's footwear was begun and arrangements were made with industry to conduct a cooperative program in this area. Evaluations of babywalkers, highchairs, and other children's furniture for strength and stability are being made. Test methods were established to protect consumers from the noise produced by such articles as cap pistols and small cannons.

SAFETY ANALYSIS. NBS has been analyzing consumer product safety to determine what there is about a consumer product that constitutes an unreasonable hazard. As a result, NBS will have the capability to develop methods for evaluating alternative governmental actions, such as voluntary or mandatory standards or user education, and for dealing with hazards identified in consumer products. Another project is the analysis of data describing accidental injuries from consumer products. This effort involves determining whether it is possible to associate hazards with the characteristics of products, rather than with an individual product.

CHILDREN'S STRENGTH. In designing safe products, especially toys, the designer must consider a child's ability to misuse the product by pulling it apart or by manipulating potentially hazardous parts. Since fundamental information on the forces children are able to exert in pushing, pulling and twisting was not available, NBS completed a study of the capabilities of 556 children, ages two through six, in day schools and day-care centers in the Washington area.

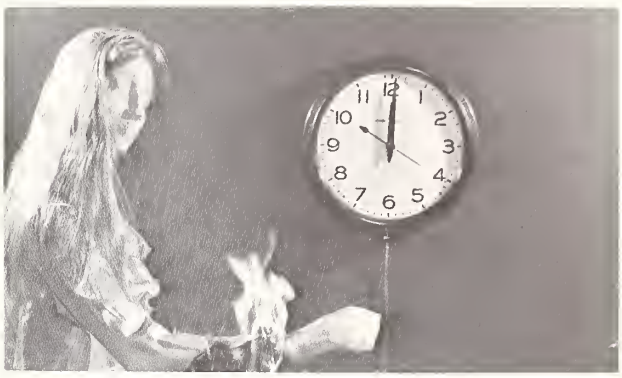
Studying the strength of children.

BURN AND FIRE HAZARDS. Many household products have hot surfaces. Whether a painful burn results from touching a hot surface depends upon both the temperature and the surface material. NBS published a study which established the relationship between the thermal properties of materials and thermal injury to human tissues. From this study and with funds from the CPSC, NBS designed an instrument that yields a single temperature measurement which is directly related to burn hazard and automatically accounts for differences in surface material and the time of contact. With this "thermesthesiometer," a product designer can test a hot surface and determine in a few seconds whether the surface will be harmless to touch, painful, or will inflict an injury.

UPHOLSTERED FURNITURE. NBS is also assisting the CPSC in reducing the hazard from fires in upholstered furniture. After alerting the public and industry through a "Notice of Possible Need for a Flammability Standard," NBS developed a small scale upholstered chair with the characteristics of upholstered furniture found in the home. Using the mock-up, a series of cigarette ignition tests measures the flammability of upholstered furniture. Objective of the work is to provide the basis for a new performance standard to minimize this fire hazard.

MATTRESSES. Like upholstered furniture, mattresses are a substantial flammability hazard when ignited. An NBS-developed test method is included in the new federal performance standard for mattresses, which took effect June 22, 1973. The standard is expected to reduce substantially accidental mattress fires started by cigarettes.

CHILDREN'S SLEEPWEAR. To protect young children from the dangers of flammable sleepwear, NBS developed the "Standard for the Flammability of Children's Sleepwear." This standard (which became fully effective July 29, 1973) requires that sleepwear in sizes 0 through 6X pass a strict flammability test. Work on a proposed standard for children's sleepwear in sizes 7 through 14 followed.



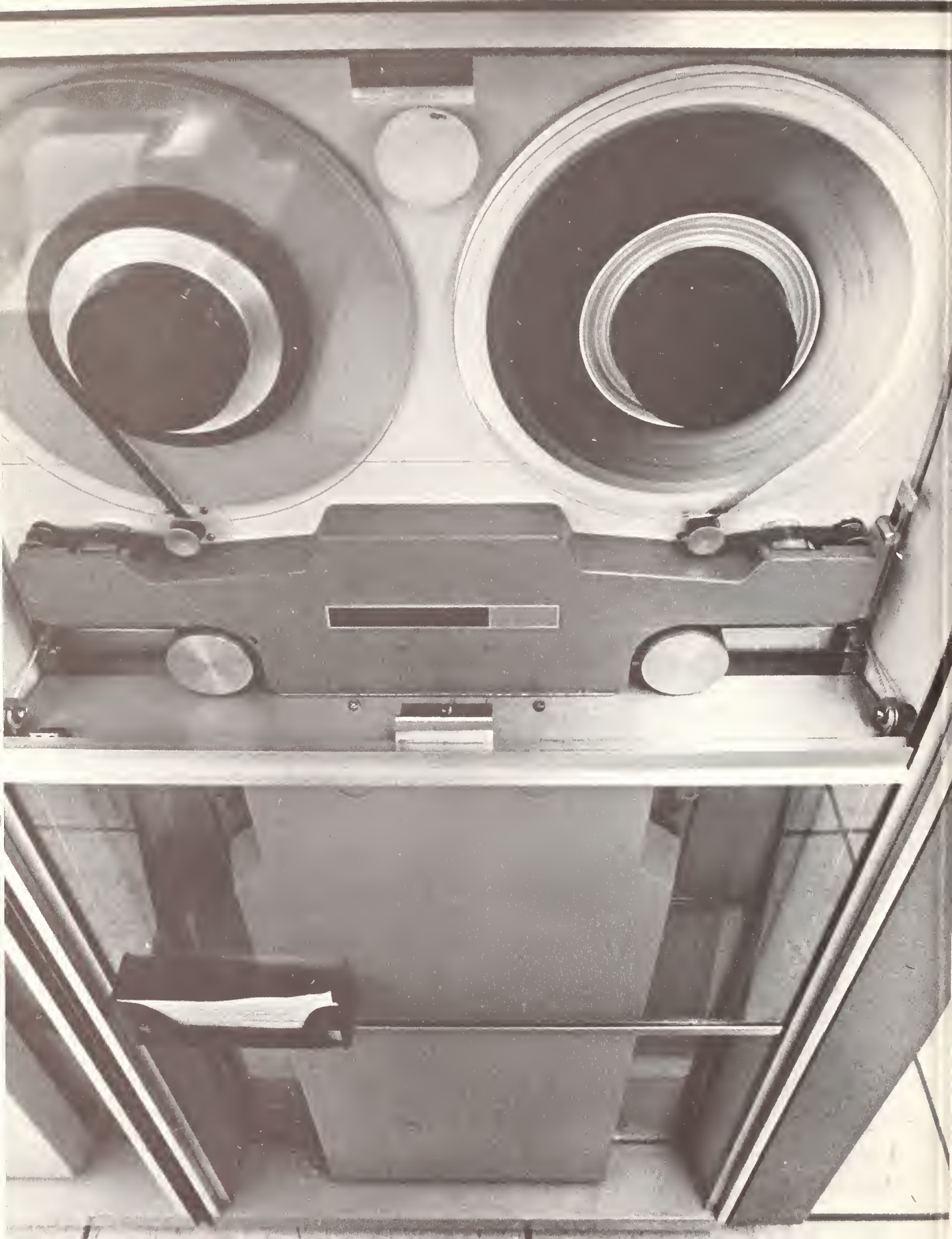
Testing the flammability of children's sleepwear.

Engineering Standards

Work on three standards was started under the NBS Voluntary Product Standards procedures: "Safety Requirements for Home Playground Equipment," sponsored by the National Association of Children's Home Playground Equipment; "Safety Requirements for Toys," sponsored by the Toy Manufacturers of America, Inc., and "Carbonated Soft Drink Bottles," sponsored by the Glass Container Manufacturers Institute, Inc., and the National Soft Drink Association. NBS works with manufacturers, distributors, and consumers to develop acceptable drafts of the standards.

NBS published a revised and enlarged edition of its "Tabulation of Voluntary Standards and Certification Programs for Consumer Products." The new edition covers 700 product areas in 17 broad categories taken from the National Electronic Injury Surveillance System of the Food and Drug Administration. It lists the voluntary national and international performance and safety standards which have been published in each product area and describes how to obtain them.

The new edition also includes, for the first time, information on standards that are still under development. The tabulation was designed for use by anyone interested in consumer problems, particularly standards-writing groups, consumer organizations, labor unions and trade associations. The broad product categories covered by the tabulation are: kitchen appliances, space heating, cooling and ventilating appliances, housewares, home communications, entertainment and hobbies, home workshop tools and attachments, household maintenance products, farm supplies and equipment, packaging and containers, sports and recreational equipment, toys, yard and garden equipment, child nursery equipment, personal use items, home structures and construction material.

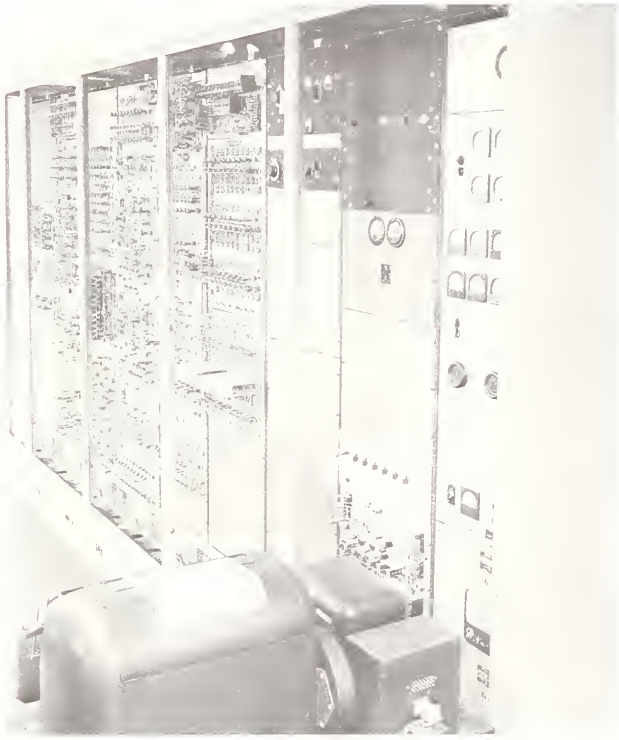


COMPUTER TECHNOLOGY

COMPUTER TECHNOLOGY

NBS has the responsibility for strengthening the nation's computer science and technology and for advancing the effective use of computers for the public benefit. The Bureau is further charged with developing standards for federal information processing while providing technical assistance to federal agencies, state and local governments, the computer industry, academia, national standardization bodies, and other special interest communities.

NBS has a long tradition of helping others apply technology. The impact of this tradition has been particularly significant in the computer field. Starting with the early assistance to federal agencies in developing applications for SEAC (Standards Eastern Automatic Computer), the Bureau's pioneer electronic computer, NBS has continued to help agencies make sophisti-



Standards Eastern Automatic Computer (SEAC)

cated use of computer technology. For example, the NBS Institute for Computer Sciences and Technology developed, as an adaptation of the automated fingerprint identification system designed for the Federal Bureau of Investigation, a computer-based footprint identification system for the President's Special Action Office on Drug Abuse Prevention. Many other examples of the efforts of NBS computer experts follow.

Privacy and Security

Public concern over individual privacy and the misuse of confidential information is rooted principally in the absence of effective means for controlling access to vast amounts of data stored in computers. NBS is responding to this concern and has initiated a broad computer security program to develop meas-

Demonstrating erasure of computer tape data with magnet.

ures to safeguard information in computer systems and in transit between computers and terminals, to protect the confidentiality of information, and to assure the security of computer systems, terminals, software and transmission facilities. The output of the program:

- A handbook for the physical protection of computerized data and computer installations.
- An executive guide for security planning and guidelines for coding data in storage and transmission.
- Techniques for controlling access to computer systems and networks, including the positive identification of individuals who are remote users of computer systems.
- Quarantine measures for determining effectiveness of security techniques.

International Trade

International trade is vital to U.S. computer companies, many of which earn substantial revenues overseas. This trade contributes more than $1.1 billion annually to the U.S. balance of payments. However, shipments of computing equipment must be carefully controlled because of the potential military use of computers.

NBS serves as a key technical advisor to the Office of Export Administration (OEA) and other federal agencies responsible for administering export control policies. In this role, the Bureau assesses and compares domestic and foreign computer technology, prepares studies of emerging trends in the computer industry, and technically assists OEA in the review of export license applications. NBS also recommends revised export control regulations through its participation in Department of Commerce technical advisory committees and other intragovernmental panels.

The Bureau is helping evaluate the role of computer technology in the growth of less-developed countries (LDC's) through a joint project with the Agency for International Development (AID). An NBS survey of computer resources and requirements in nine LDC's is being used to formulate pilot computer programs for future AID support. NBS is also assisting U.S. delegations to the United Nations and to the Organization for Economic Cooperation and Development in developing reports and policies pertaining to the use of computers in development.

Networking

Computer networking is revolutionizing the use of computers today. Networking involves the marriage of computers and communications which enables the effective sharing of expensive computer-based resources. These resources include information or large data bases, large computer programs, and the computer hardware itself. Current impediments to computer networking are the lack of network performance measurement tools and the difficulty of accessing network-based resources.

NBS has designed and developed a unique "network measurement machine." This tool measures the service provided by computer networks by identifying and recording information during a user's interaction with a network. These data are then processed through a special computer analysis program resulting in such measures of network performance as system response time and communication utilization. NBS developed guidelines which will enable computer experts to design their networks for optimum efficiency.

The problems associated with network access are being met through the development of a "network access machine." This new device will intervene between a network user and multiple network services to execute automatically complex procedures necessary to connect to, log on, and use a wide variety of network resources. This machine will afford a better understanding of the development of network protocols (common procedures for user interaction with computer networks).

Special message processors enable NBS to reach computers throughout nation.

Data Entry For IRS

NBS has developed a prototype automated system which is processing taxpayers' remmittances for the Internal Revenue Service (IRS), is connected through an NBS-developed controller to an on-line computer and automates a multi-step manual processing sequence. Using the system, an operator can, in one quick, continuous process, print audit trail information on the face of the taxpayer's check, place an IRS endorsement on the back of the check, and print and affix a label on the taxpayer's tax return form. The prototype systems delivered to IRS's mid-Atlantic region service have enabled remittances to be processed 10 times faster than with conventional methods.

COBOL Compiler Testing

A new service for testing COBOL programming language compilers acquired by the federal government was initiated by the Department of Defense under an agreement with NBS. These compilers are used by computer users to adapt the widely used COBOL programming language to their own specific machines.

The testing service will provide a major facility to federal data processing installations for validating a compiler against required levels of the federal COBOL standard. NBS has the responsibility for interpretation of the standard. The testing service is a significant step in reducing redundant testing of COBOL compilers and improving compatibility and interchangeability of COBOL programs, as well as improving the quality of COBOL compilers used by federal installations.

Automation In Retailing

NBS is providing technical assistance to the retail industry in its efforts to adopt automation technology. Automation can both expedite and reduce the costs of controlling goods from point of manufacture through point of sale to consumers while simultaneously stockpiling information about these transactions.

Manual merchandise control giving way to computer systems.

NBS Pattern Recognition System

An NBS-developed computer approach is processing earth-resources data gathered by the National Aeronautics and Space Administration ERTS-1 satellite. The Bureau originally developed the technique for recognizing patterns in biological cells being scanned under a microscope. ERTS-1 observes light being radiated from the earth's surface. It generates 28 thousand million bits of measurement data per day, stored in the form of digital pulses on tape. The data contain a great deal of potentially valuable information relating to the conditions of agricultural crops, urban development, water resources, geological structures and land use distribution.

New England Experiment

NBS is collaborating with the Numerical Control Society in an experiment to promote the diffusion of automation by improving the market for the technology. A computer-based information service on available manufacturing capacity will be created and tested in the New England region. The objective of the information service is to improve communication between product industries and supplier industries, matching manufacturing needs with the productive capacity that can fulfill those needs. Using this service, industries will be able to utilize better their existing capacity and, eventually, to justify and afford new automation equipment—numerical control machine tools, for example. The improved market will "pull" new process technology into application. NBS played a catalytic role in the creation of this experiment, and is helping provide standards to insure transferability of successful results to other regions and industries.

Automation Technology

Industrial robots and numerically controlled machine tools are at the forefront of the revolutnionary application of computers to control machines in manufacturing. Essentially the same sensor and computer control technology can be applied to computer based automation systems for operation in environments hazardous to man. Undersea exploration and drilling

The pincer hands of a computer activated robot mimic a scientist's movements.

systems for operation at great depths are made possible by this technology, as are automated long wall coal mining and rapid tunneling systems needed to achieve national goals in energy and transportation. NBS is developing performance evaluation guidelines for advanced automation systems.

Lab Automation

NBS is making a coordinated effort in applying minicomputers throughout its laboratories, both for the operation of scientific instruments and for the collection of scientific data. This program is to improve the efficiency, accuracy and effectiveness in NBS metrology activities related to the national measurements system.

Computer Use In Vote Tallying

Guidelines for computer systems used in vote tallying will be developed by NBS under contract to the

General Accounting Office. After surveying jurisdictions which have employed computers in conducting elections, NBS will recommend guidelines for election computer systems which assure accuracy, prevent fraud, and provide effective decision-making information to election officials.

Turning A Matrix Inside-Out

A problem which computers are frequently asked to solve is the inversion of a matrix, or the solution of a system of linear equations. Many needs in physics and engineering require that the computer perform this key step with reliable accuracy. For large matrices (order 100 or more) it becomes increasingly difficult to perform the inversion operation with known accuracy, using a reasonable amount of expensive computer time.

A Bureau study, using inexpensive methods of error estimation developed at NBS, considered six widely-used matrix-inversion algorithms. The following conclusions were reached: (a) Two out of the six methods were superior in known accuracy, with a trade-off against extended computer time which could be clearly calculated. (b) For matrix order less than 50, the user will find distinct advantages to iterating the corrections. (c) At matrix order 100, the user must judge carefully when iteration has reached the point of diminishing usefulness.

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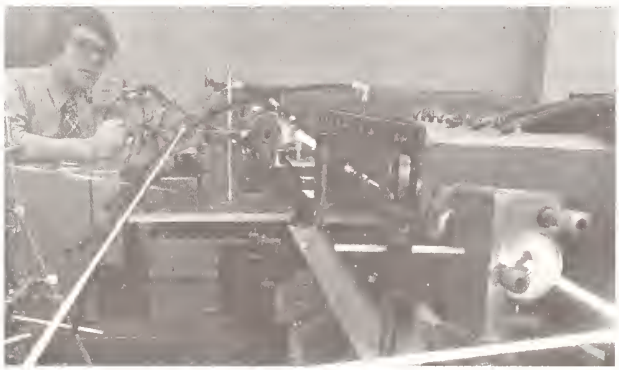
5102 EC

MATERIALS

MATERIALS

Materials are the lifeblood of our economy. It is estimated that $150 billion worth of energy and processed materials are used each year in the U.S. Put another way, this accounts for some 18,000 kilograms of materials annually for each U.S. citizen. In order to achieve progress and improve the quality of life, man must improve the qualities of his materials or produce new ones. From synthetic drugs to made-made fabrics, we have created materials to suit our needs. But in order to increase the durability, reliability and performance of materials in service, a thorough and quantitative knowledge of the basic behavior of all types of materials is needed.

NBS research on the properties of materials covers a broad range—from fundamental studies of atomic and molecular reactions to bulk properties of plastic sheets, from hundreds of degrees below zero to thousands of degrees above, from the basic properties



Using dye laser to detect free radicals.

of simple substances such as hydogen to the behavior of complex technological materials such as coal.

New Techniques For Laser Chemistry Studies

A new tool for studying basic chemical reactions has been developed at the Bureau. For the first time, NBS scientists linked a laser and a mass spectrometer together. The spectrometer analyzes chemical reactions caused by the laser beam striking streams of gases. Using the laser light to interact with specific chemical bonds in various molecules could be a way of producing novel materials for special applications. The ability to study the chemical reactions as they occur should help to guide such research.

In a separate project, NBS scientists developed a powerful technique for studying free radicals using a dye laser. Free radicals are electrically charged fragments of molecules which are involved in many chemical reactions; they are very short-lived intermediate products in the reaction and must be observed on the run. Yet understanding their behavior is essential to pollution studies, fire research, high temperature chemistry, stratospheric chemistry, laboratory investigations of planetary atmospheres, and development of new lasers. In the new system, free radicals are actually produced inside the laser tube and are analyzed by the way they absorb the laser light.

Electron Recombination Reactions

NBS scientists have made the first accurate determination of the rate at which positive organic ions recombine with electrons and with negative ions after being disrupted by intense doses of electron radiation. Not only electrons, but gamma rays, x-rays, and alpha particles produce electrically charged species in materials through which they pass. Knowledge of the reactions which occur will make possible better selection and use of materials in high radiation environments. Among the chemical reactions induced by radiation are those responsible for corrosion in nuclear reactors, the destruction of cancer cells and the strengthening of plastics.

Bronze horse verified as Fifth Century B.C. antiquity.

Materials Science and Art

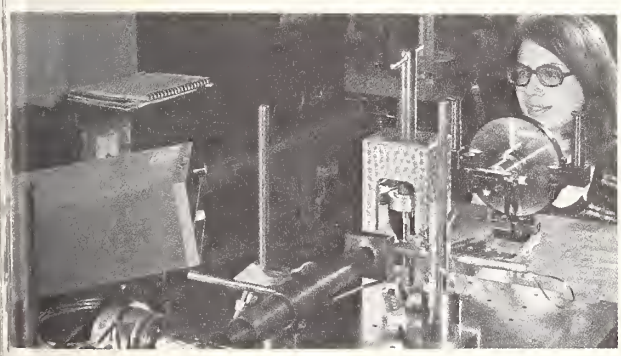
A famous bronze horse owned by New York's Metropolitan Museum of Art was recently challenged as a 20th Century fake. With the assistance of materials scientists at NBS, the horse was indeed proved to be a work of antiquity. Using new techniques of high-accuracy mass spectrometry, the NBS scientists identified the source of the lead used in the statue and showed it to date from the Fifth Century B.C. Because the method is non-destructive, and because lead was so widely used in ancient times, the method should prove generally useful in dating artifacts by analysis of glasses, glazes, white lead pigments and leaded bronzes, silvers and gold. NBS is building a data bank on the characteristics of leads from various locations and time periods to aid future identifications.

In a related project, thanks to the expertise of NBS metallurgists, the spectacular gold-plated statues framing the roadways west of the Lincoln Memorial in Washington again gleam in the sun. Concerned over the bad discoloration of the statues, due to corrosive deterioration, the National Park Service, U.S. Department of Interior, called on NBS to appraise the condition of the statues, which are familiar to tourists visiting the Nation's Capital. NBS was also asked to recommend procedures that could be used in restoring the statues to their original luster.

Following a thorough inspection of the statues, the NBS team presented the Park Service with an evaluation of several restoration procedures. A brush-electroplating technique was selected by the Park Service because it would duplicate the original gold color and provide a long-lasting surface.

How Cracks Grow

A novel method for testing structural design and for predicting the lifetime of such diverse products as turbine blades, space ship windows, soft drink bottles and other brittle materials was developed by NBS. It is based on analysis of how cracks grow. The research could lead to safer glass bottles, for example, with a consequent reduction in injuries. Compatible with production line techniques, the new method should make possible general tests of many types of pressurized glass containers and other brittle materials.



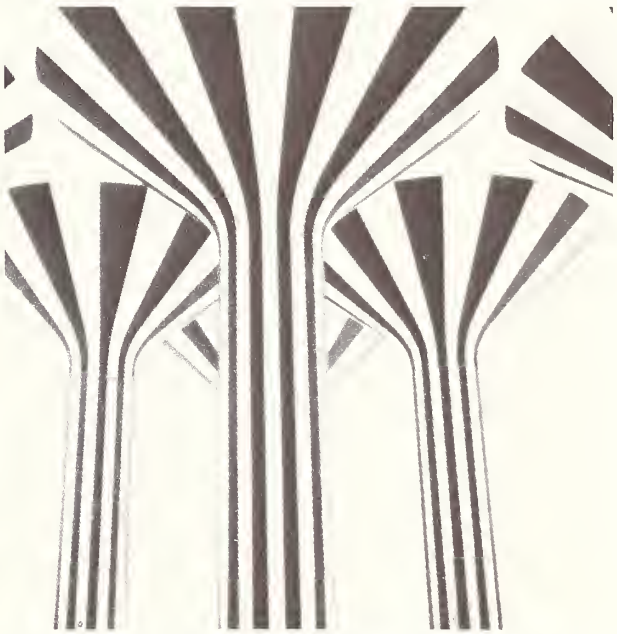
Using polarimeter to determine relative stress-optical coefficient of glass.

Strains In Glass

Often, the measurement capability developed at NBS is made available to those who need it in the form of Standard Reference Materials (SRM's). These SRM's are characterized for composition, melting point, optical and many other properties and serve as bench marks to check our measuring methods and systems. Recently the Bureau issued a new set of glass SRM's, certified for their stress-optical coefficient, to be used to detect strains in glass by changes in the way light passes through it. With the SRM's as a starting point, a manufacturer can more reliably inspect such products as safety glasses, bottles, tempered glass windows and glass-to-metal seals.

Corrosion Protection

Deicing salts have been responsible for the corrosion of steel reinforcing bars and the disintegration of concrete in highway bridges. Maintenance of these bridges could run as high as $200 million yearly. At the request of the Federal Highway Administration, NBS staff developed an epoxy coating for the reinforcing bars, to be tried experimentally in 40 highway bridges.



Water tower corrosion in Kuwait investigated by NBS personnel.

In another research effort, NBS, the U.S. Army Corps of Engineers and the U.S. Naval Civil Engineering Laboratory, with the support of the American Iron and Steel Institute, are investigating the corrosion behavior of protected carbon and low alloy steel piling in seawater. Ninety-three "H" and pipe pile specimens, 10.7 meters (35 feet) long, were embedded in the Atlantic Ocean floor off the coast of Dam Neck, Virginia. The results of this study, which will take about 15 years to complete, will demonstrate which systems are best for protecting steel piles in seawater.

NBS also has devised a new method for determining the relative amounts of austenite and ferrite in welds and castings. Stainless steel welds are primarily austenite, but some ferrite is beneficial to improve the strength and resistance to stress-corrosion cracking. Too much ferrite leads to brittleness and reduced corrosion resistance. The new method avoids the problem of austenite being converted to ferrite while machining the sample to a proper thickness for the test. The test method is also non-destructive.

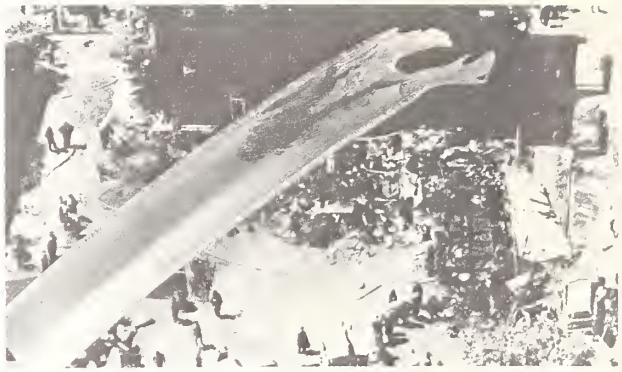
Vapors from such highly corrosive substances as molten aluminum and iron can be contained for spectroscopic investigation in a newly designed heat-pipe oven developed at the Bureau. This new oven greatly expands the applicability of the original capillary wick type of heat-pipe oven developed in 1969 at NBS Boulder Laboratories. The new design, which utilizes centrifugal force instead of a wick to return the condensate, was developed at the request of the Naval Research Laboratories for a device to measure the photoionization cross section of atomic iron.

Polymer Electrets

Electrets, electrical analogs to permanent magnets, are present in a new class of piezoelectric and pyroelectric polymeric materials that show great promise in novel applications, such as intrusion detectors. NBS has started an experimental and theoretical program to understand their properties. A theory has been developed to predict the behavior of electrets that should help promote their use as sensitive, rugged, easily made and cheap elements for such diverse applications as thermal radiation detectors, night vision devices and sonar transducers.

Glass Reinforced Plastic

Flexible glass reinforced plastic (GRP) rod and rope, similar to the material in fiberglass fishing rods, is widely used for guy lines in radio towers. The commercial grips which attach the ends of the guys often cause failures by crushing the material. NBS has developed a new "easy squeeze" fitting which prevents this type of failure.



Piece of tubing from fatal oxygen truck explosion.

Controlling Metal Combustion

NBS Boulder is studying the way metals burn in liquid and gaseous oxygen in order to develop safer designs for oxygen-handling equipment used in industrial, aerospace and research situations. Because metal combustion is not well understood, no adequate means for controlling it exist. The need for data was tragically pointed up by an oxygen truck disaster at the Brooklyn Memorial Hospital in 1970.

New Cryogenic Materials

Manufacturers of superconducting generators and motors have been rather seriously hampered by insufficient and, in some cases, total lack of relevant data for proper design to insure successful long-time operation. Because the operating temperature of superconductors is near that of liquid helium (4 kelvins), the Advanced Research Projects Agency (ARPA) has contracted with the Cryogenics Division of NBS to study and measure the thermal and mechanical properties of structural materials at 4K. Special emphasis will be placed on fracture properties. Fracture toughness, fatigue, and fatigue crack rate data at 4K, currently non-existent, are urgently needed.

The three-year program will evaluate the metals currently in use, studying their toughness, fatigue, and fatigue crack growth properties. Additional thermal and mechanical property data as well as a literature compilation will be obtained through outside contracts with other low temperature laboratories.

Better Spectroscopy Of Interacting Excited Systems

NBS Boulder has devised a predictive capability for the intensity of the molecular continuum radiation used, for example, in high-intensity high-pressure industrial and highway lamps. Researchers of a large electrical equipment manufacturer have reported using

these techniques to predict the radiation emitted by high-pressure mercury arcs. Previous methods led to "a gross over-estimate" of the total radiation, while the new method allows prediction to within a factor of two. These results are applied to the company's program of lamp optimization with "significant results of commercial value."

Ammonia-Thermodynamic-Properties Tables Improved

NBS has long maintained a strong interest in the thermodynamic properties of ammonia, and about half a century ago (1913-1923) undertook extensive research relating to these properties, culminating in the publication in 1923 of NBS Circular 142, "Tables of Thermodynamic Properties of Ammonia." The present effort extends by many orders the limited temperature-pressure range of the earlier circular in order to satisfy needs of today's technology.

Some important results of technical interest have already been published. In part, these utilize the powerful theoretical tools of statistical mechanics to establish the extraordinary quality of the early measurements made at NBS over 50 years ago. One consequence is a collaborative effort currently underway with the University of Karlsruhe to utilize such measurements for determining the absolute temperature scale. Of equal significance is a new and powerful technique to establish the accuracy of derived thermodynamic properties, to the end that close tolerance can be assigned to the accuracy estimates for new tables published in FY 1974.

slim jim
PIZZA
5 PACK
slim jim
PIZZA
BEEF & CHEESE SNACKS
5 PACK

MEASUREMENT STANDARDS

MEASUREMENT STANDARDS

NBS is the agency in the federal government responsible for our national measurement standards, such as time, length, weight, and temperature. NBS not only maintains standards for the units of measure, it also helps to improve the standards and measurement techniques covering a range of values to the required level of accuracy. NBS also develops methods for getting those national measurement standards to everyone who needs them. An important part of the job is coordinating the U.S. measurement system with the international measurement system for both scientific and commercial exchange.

Standards Affecting Consumers

In its New State Standards Program, NBS has been supervising the replacement of all of the standards for mass, length, and volume originally provided to the states by the federal government 100 years ago or more. The sets of standards are provided in both customary and metric units. By June, 1974, 42 states had received new standards.

Demonstrating technique for determining accuracy of aerosol can labels.

One persistent problem facing weights and measures officials is the need for testing weight and volume of hard-to-handle packaged products, such as paint, varnish and lacquer. Recently, NBS developed a procedure by which these officials can determine whether the stated weight or volume on the label of the cylindrical containers is accurate and the contents are correctly advertised.

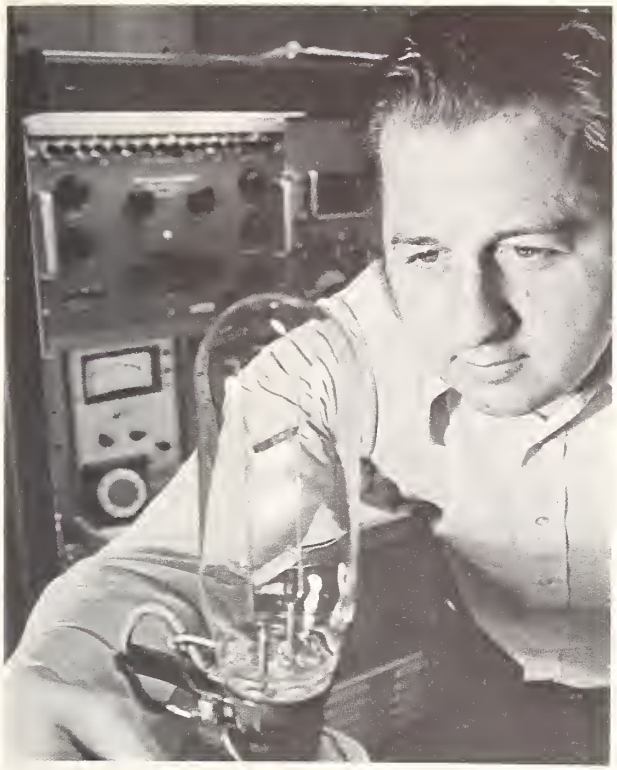
In response to a request by the California Bureau of Weights and Measures and in cooperation with the Compressed Gas Association, Inc., of New York City, NBS also prepared a tentative code for cryogenic (supercold) liquid measuring devices for the National Conference on Weights and Measures (NCWM). The Conference is a national forum for promoting uniformity of requirements and methods by consensus among the states and local jurisdictions, which hold the regulatory authority for weights and measures. This cryogenic code gives specifications, tolerances and other technical requirements for the devices to be used by weights and measures enforcement officials. NBS has also assisted the NCWM in the preparation of the specifications and tolerances which allow the conversion of meter indicators on liquid petroleum gas-vapor meters to either cubic feet or cubic meters.

In another measurement area, NBS prepared, at the request of NCWM, a procedure for checking the accuracy of quantity statements on packages of polyethylene sheeting. including net weight, dimension, length, and thickness.

New Length Measurement Standards

Since 1960, the international standard of length—the meter—has been defined in terms of a wavelength of light. A complex of mirrors and lenses is used to count off 1,650,763.73 wavelengths of the orange-red light given off by the element krypton. The search for improved length standards depends on finding brighter light sources with ever more stable wavelengths, like lasers.

Iodine vapor and methane gas absorb light at very specific and stable wavelengths. NBS has used these gases as detectors to identify specific wavelengths and to tune lasers to give off just those wavelengths. The resulting stabilized lasers show such promise that an international body, the International Committee on Weights and Measures, accepted two laser wavelengths for use as secondary standards of length. Some day soon, because of NBS research, such a stabilized system may replace the krypton wavelength as the international standard.



NBS standard of luminous intensity is used for industry calibration.

New Value For Speed Of Light

The speed of light (c) has been determined more accurately than ever before by scientists at the Bureau's Boulder Laboratories. They found that light travels at a velocity of 299,792.458 kilometers per second, ±1.1 meter per second (186,282.397 miles per second, ±3.6 feet per second). The new value is 75 times more accurate than the value accepted for the past 15 years.

The experimental scheme for measuring *c* has two parts: one is the frequency measurement of the 3.39-micrometer emission of a helium-neon laser stabilized by saturated absorption in methane, and the other is a wavelength measurement of the same laser in terms of the krypton wavelength standard. Multiplying the frequency by the wavelength gives the speed of light.

Laser Spectroscopy

NBS has continued its long-standing reputation as one of the world's leading spectroscopy laboratories by resolving the hyperfine structure of a methane molecular absorption line to a part in 10^{10}. The details of the line structure shed light upon the physics of the molecule, and are part of the effort to develop better standards for both length and frequency.

Measuring In 3-D

In the real world, length measurements are seldom made in only one direction. Machined and manufactured objects like gears, for example, have three dimensions and shapes and contours which must be carefully measured and controlled. Such measurements represent one of the most challenging areas of modern metrology.

Measuring three-dimensional objects.

With the advent of computer-controlled machine tools, 3-D metrology has grown vastly in importance. NBS has established a special program, including a laboratory and new machine, to meet industry's need for 3-D measurements. The NBS measuring machine can now supply dimensions of complex parts to 2.5 millionths of a meter proven accuracy, over a volume of 60 by 70 by 25 cm. The next stage of development will be to connect its operations to a dedicated minicomputer to minimize operator error and increase efficiency.

Interatomic Dimensions

A highly accurate extension from the visible wavelength of a stabilized laser, to x-rays of wavelength 10,000 times shorter, has been carried on by NBS. The experiment involved smoothly translating a piece of a perfect silicon crystal more than 100 optical wavelengths. Combined with a high-precision determination of density and isotope abundance, the measurement determines Avogadro's number to unprecedented accuracy and precision.

Keeping Time—The Atomic Clock

The fifth generation of atomic time standards has been completed for test at the Boulder Laboratories. The Bureau pioneered with the first machine to use the atom for time measurements in the late 1940's

when Dr. Harold Lyons used ammonia molecules as "pendulums." Currently, the atomic clocks are tuned to the oscillations of cesium atoms. The new model, NBS-5, promises to be accurate to at least one part in 10^{13}.

A new technique for determining major error sources in commercial atomic clocks, applicable to analyzing the new NBS-5 atomic clock, was also developed at the Bureau. The new method should greatly improve manufacturers' abilities to identify misaligned cesium clocks before they leave the shop.

In 1973, an international comparison of atomic clocks found the difference between Atomic Time maintained by NBS and International Atomic Time maintained by the International Bureau of Time of Paris to be 1.2 microseconds, well within the allowable tolerance. This same comparison revealed that the national frequency standards of Canada and Germany agree with that of NBS to within two parts in 10^{13}, the first time that such precise agreement has been achieved between three such independent primary standards.

TV-Time Petition Sent To FCC

The Secretary of Commerce, on behalf of NBS, petitioned the Federal Communications Commission to change the television broadcasting rules to permit sending time, frequency and other information over the nation's TV networks. The petition would allow the networks to broadcast encoded information on one line of the blanking interval (the black line between TV images seen when the picture "rolls").

Captioned TV for deaf viewers.

The TV-Time System, developed by scientists and engineers at the Boulder Laboratories, generates a signal which can be carried on one line of the blanking interval during broadcast. Special electronic equipment at the broadcast station and complementary equipment on the television set allow information to be encoded and decoded to provide useful information in caption form on the television screen. Only specially equipped sets can decode the signal.

NBS developed the system to provide accurate information to the thousands of commercial and scientific institutions which require precise time and frequency. The signals will also provide a means of captioning television programs for the deaf or for foreign-speaking audiences. Channel identification, weather and disaster information, and other important information could also be transmitted by the NBS TV-Time System. The signals can be used to reset electric clocks automatically after a power failure, and can help analyze power failures on a continent-wide basis. They can be used to determine accurately position on the earth and are useful for many computer and business operations.

The NBS TV-Time System was made part of an exhibit at the Smithsonian Institution.

New Users For NBS Time Broadcasts

A new portable radio on the U.S. market receives NBS radio stations WWV, WWVH on 10 MHz at the push of a button. The manufacturer's advertisement read: "The world's most accurate timepiece. Only $34.95 . . . just push the button and instantly receive the official time boadcast of the National Bureau of Standards' atomic clock from Boulder, Colorado, 24 hours a day."

Many new users are reported for the NBS high accuracy time boadcasts on WWV, WWVB and WWVH. Over a million calls to WWV's telephone time-of-day service alone have been logged in the first three years, with the rate climbing from around 1,000 calls per week in 1970 to about 11,000 per week in 1973.

Part of the reason for this growth is the variety of services offered. WWV is now offering storm information for the eastern Pacific, similar to the broadcasts for the entire Pacific broadcast on WWVH, in addition to information about Atlantic storms, broadcast on WWV.

Another new service offered by WWV and WWVH has been the announcements of Skylab experiments. Both stations broadcast information about current and upcoming experiments using the Apollo Telescope Mount.

Station WWVB, which boadcasts on the low frequency of 60 kHz, began uninterrupted transmission on July 4, 1973. Two user groups are particularly important: members of the North American Power System Intertie Committee, who synchronize the frequency control of their electric power networks by means of WWVB; and earthquake monitoring networks, especially in California, which use the broadcast signals to place seismometer and building-motion sensors in different locations on a common, accurate time scale.

Most Accurate D.C. Electrical Comparator

The world's most accurate device for comparing direct electrical current has been developed by Bureau scientists and engineers. Based on a superconducting principle, the device extends the accuracy previously possible with similar designs. In practical use, it will provide a very accurate standard for checking properties of measurement transformers which are important parts of the nation's power distribution network.

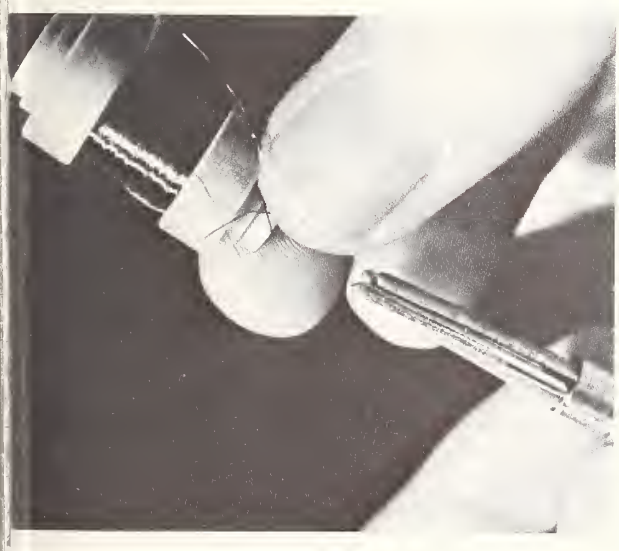
Better Integrated Circuit Reliability

NBS has started a five-year program to improve the measurements involved in the production of integrated circuits, the heart of most sophisticated electronic instruments. The project was undertaken at the request of the Department of Defense, but results should be useful to industry. For example, it is estimated that only three percent of the silicon being used in the production of integrated circuits ends up in acceptable working devices. More rapid and accurate measurement in the manufacturing process could cut such losses.

NBS also improved the method used for measuring the resistivity of silicon wafers used in making solid-state devices. The Bureau will soon make available silicon wafers with standardized, certified properties to serve as standards against which manufacturers can check their measurement procedures.

Low-Temperature Research

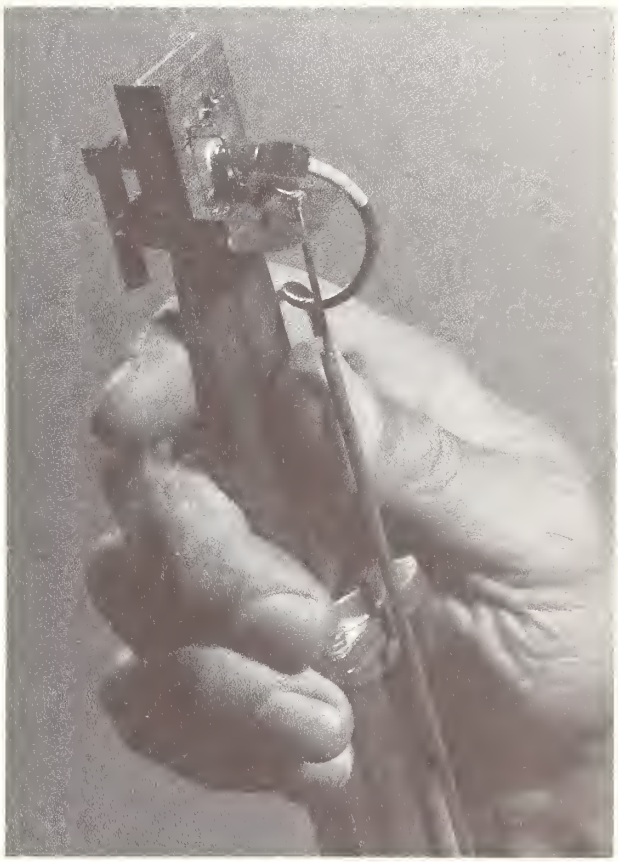
A superconductive device, providing five fixed-point reference temperatures near absolute zero, has been developed at the Bureau. The device, sold as a Standard Reference Material, should be widely useful for calibrating helium dilution refrigerators, determining the temperature stability of equipment and the temperature reproducibility of physical phenomena, and providing on-site calibration of secondary thermometers. Its most important aspects, however, may lie in its use in helping to define the thermodynamic temperature scale below 20 K, and in demonstrating the feasibility of solid-state phenomena as thermometric fixed points. Composed of five high-purity elements—lead, indium, aluminum, zinc and cadmium—the device provides fixed points near 7.2 K, 3.4 K, 1.2 K, 0.8 K and 0.5 K.



Superconductive device provides five fixed-point reference temperatures for cryogenic measurements.

Electromagnetic Metrology

For the first time, a purely quantum mechanical phenomenon has been made the basis of a practical rf measurement. Scientists at NBS Boulder have developed a new sensor that is a variant of the Superconducting Quantum Interference Device (SQUID). With it they have measured changes in rf attenuation. The new sensor uses the flux quantum as a fundamental unit of measurement.



Device for measuring attenuation of high-frequency electrical signals.

Optical Rotation Analysis

Sucrose—the most inexpensive sweet sugar—is the most commonly used sweetening agent in home use. The entire 10 million tons of cane and beet sugar (sucrose) used by the United States each year are bought, sold and the tariff set and paid on the basis of a standard for rotation of polarized light calibrated by NBS.

Bureau scientists have developed an instrument to determine more accurately the rotation of these standards. Using a photoelectric azimuthal polarimeter with electronic readout, they obtain high accuracy and avoid operator bias. Similar optical rotation analyses are increasingly used in quality control procedures for the pharmaceutical industry.

Vibrational Energy Levels

NBS conducted the first demonstration of using a laser to excite vibrationally carbon monoxide (CO) and nitric oxide (NO), and the first determination of the vibrational energy transfer between colliding molecules of each of these compounds. The work demonstrated that a frequency-doubled CO_2 laser will vibrationally excite the gases to energy levels corresponding to temperatures far above those attained by other methods. This leads to the possibility that certain chemical reactions can be dramatically accelerated, resulting in a "new chemistry" which could make certain chemical processes more economical, and make new processes feasible.

Advances In Antenna-Measurement

Among the more interesting recent developments in NBS' microwave measurements are gain calibrations on two Jet Propulsion Laboratory (JPL) S-band gain-standard horns on the outdoor extrapolation range located on the mesa behind the NBS Boulder Laboratories. These horns are being used by JPL to calibrate the gain of the Goldstone deep-space tracking antenna and similar units, in cooperation with a microwave beacon left on the moon for just this purpose.

The *near-field scanning* method of determining antenna pattern and gain has been applied to array antennas and the theoretical groundwork has been laid for near-field measurements on spherical surfaces. The work on array antennas is oriented toward development of reliable methods of checking aircraft phased array antenna systems *in situ* on the flight line.

In cooperation with the Forest Service of the Department of Agriculture, NBS is studying the use of microwaves to determine the depth and structure of snow pack to try to predict avalanches.

Microwave antennas at Crater Lake National Park, Oregon test site.

Measurement Assurance Programs

Relatively new at NBS are measurements assurance programs in which a cooperative arrangement is set up with users of calibration and reference services so that NBS checks quality control in their useful output of measurement services.

Customers for the measurements assurance program in mass standards now receive with their report of calibrations a full laboratory-notebook-type account of the procedure followed at NBS, together with background information and helpful suggestions as to how the user might reconstruct the procedure for himself. Comparison tables and statistical information on the class of standards being calibrated are furnished, in printout, from a computer program. A similar, but less detailed, calibration report is furnished with calibration of piston gauges. In the field of statistical control for experimental design, two monographs have been published on mathematical design of experiments.

NBS also began delivering calibration certificates for bolometer mounts, based upon measurements made by a new Automatic Network Analyzer system. This marked a major milestone in a program to automate basic measurement capabilities. Calibrations are now being made in 5 minutes that formerly required 5 hours of the time of a very meticulous, highly skilled technician.

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